MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph. D.
Director

BULLETIN 47

ADAMS COUNTY MINERAL RESOURCES

GEOLOGY
By
FRANKLIN EARL VESTAL, M. S.

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

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

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MISSISSIPPI GEOLOGICAL SURVEY

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LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi
April 11, 1942

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

Gentlemen:

Herewith is Bulletin 47, Adams County Mineral Resources—Geology by Franklin Earl Vestal, M.S.; Tests by Thomas Edwin McCutcheon, B.S., Cer. Engr.—which is published as a fulfillment in part of the sponsorship pledge of the Mississippi State Geological Survey, necessary to obtain Federal-WPA funds for the various county geological mineral surveys of the State. As stated elsewhere, the report would not have been possible without the valuable cooperation of the Adams County Board of Supervisors, the Natchez Association of Commerce, and the Adams County citizens in general—all of whom acted as cosponsors to the State Geological Survey.

As usual the first part of the Geologic section is devoted to the sequence of the geologic formations, the determination of which was exceedingly laborious in the Loessal Mississippi River Bluff Region of steep rugged topography; and the second part to economic geology. Both show the extremely painstaking care of the author. The Test section is devoted almost exclusively to the clays.

Some of these clays have such high strengths as to be outstanding. They should make excellent bonding material for Foundry moulding sand and excellent material for Drilling muds. It is the hope of the State Geological Survey that they will be developed by state citizens and capital.

Very sincerely and respectfully,

William Clifford Morse,
State Geologist and Director

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GEOLOGY

FRANKLIN EARL VESTAL, M.S.

INTRODUCTION

Adams County is in the southwestern corner of Mississippi, roughly between the parallels of 31 degrees and 32 degrees north latitude, and the meridians of 91 degrees and 92 degrees west longitude (Fig. 1). It is bounded on the north by Jefferson County, on the east by Franklin, on the south by Wilkinson, and on the west by Mississippi River which separates it from the state of Louisiana. The county has a very irregular shape, due chiefly to the erratic Mississippi on the west, the only slightly less erratic Homochitto on the south, and Fairchilds Creek along the northern boundary for most of its length.

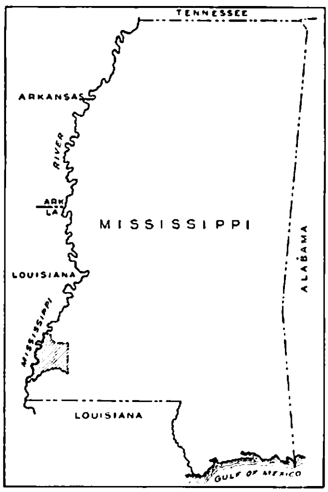

Figure 1.—Location of Adams County.

The extreme length of Adams County is about 40 miles, the maximum width about 25 miles, and the area approximately 448 square miles.[1] The population, according to the 1940 census, is 27,238, more than half of whom live in Natchez, the only city.[1] The chief occupations of the people outside the city of Natchez are farming, stock raising, dairying, and lumbering. Only a relatively small part of the area of the county is under cultivation; cotton is the chief crop, corn, second in importance. Some truck crops are grown, especially in the vicinity of Foster. In general the cultivated lands are parts of large plantations, and are tilled by tenants; but there are a number of small holdings. Many of the ownership rights date from the time of the old Spanish land grants, and property lines apparently have been drawn as the accidents of the dealings of men with men and nations with nations have determined. Except on the Mississippi River plain and a strip along the eastern boundary of the county, the civil survey system extends no farther than townships and ranges. The result is a patchwork of tracts of various shapes and sizes, with very few regular mile square sections (Plate 1). A considerable area is of too high a slope for cultivation, and is used as pasture land or left in forest. Beef cattle roam almost every part of the county, and at least four or five large dairy farms are operated in the vicinity of Natchez. Natchez is also a market for horses and mules. The lumbering industry still flourishes, although most of the best timber has been cut. Trucks loaded with lumber or with huge logs are a common part of the highway traffic, and barges of the same kind of freight are not uncommon on the river.

The routes of travel and transportation are: Mississippi River; the Illinois Central (old Yazoo and Mississippi Valley); the Mississippi Central; and the Natchez and Southern Railroad and the Missouri Pacific, connecting to the east; and public roads and highways.[22] The public road system includes two pavement highways, U. S. 61 which traverses the county from its northeastern boundary to its southern, and U. S. 84, which leads southeastward and eastward from Washington to beyond the county limits, and westward from Natchez across the river; and also a number of gravel roads, chief of which are Liberty Road, old Highway 61, old Woodville road, and Pine Ridge road. All the main roads are connected by local roads, many of which are graveled, at least through part of their length. The Natchez-Vidalia bridge across the Mississippi, recently completed, is an important link in the highways. Before it was built ferries plied between Natchez and Vidalia. The Natchez Trace, a historic route for trade and travel, is being reconstructed in Adams County, as in numerous other places along its length, and promises to be re-opened some time in the future.

Natchez, the county seat, stands on the bluff of Mississippi River at the point of a big eastward bend of the river and the foot of a big westward meander. It is one of the oldest towns in the United States, and prides itself on its history and places of historic interest. Fort Rosalie, built by the French in 1716, was the first settlement by white men on the present site of Natchez. The territory was held by the French, English, and Spanish in turn, and was occupied by American troops in 1797. Natchez was the capital of the territory till 1803, then Washington, 5 miles a little north of east of Natchez, was the seat of government till 1818.[2]

Natchez came into being largely because of the geographic and topographic features of its location. During the years between the Revolution and the Civil War, it became a commercial and cultural center of the old Southern type, built around the plantation system in which large land holdings, cotton, and slave labor figured prominently. "The heart of the old South," a slogan used today in connection with the annual Natchez Pilgrimage to the numerous antebellum mansions in and around the city, is accurately descriptive.

Natchez early became an important river port, shipping point for cotton, and market for up-river products. This trade grew to large proportions during the steamboat era of the 19th century,[2] but declined following the war between the states. Today a few steamboats ply up and down the river, carrying assorted cargoes or pushing barges loaded chiefly with logs, gravel, coal, lumber, and other bulky freight. A few years back, the town was the site of some of the largest cotton mills of the South, as well as of great cotton warehouses. Natchez today depends for its support and its position in the commercial and industrial world on the cotton business, much reduced; the lumber and sawmill business; meat-packing at a large plant on Liberty Road in the edge of town; a large tire plant; a large garment factory which operates now and then; and numerous smaller business or industrial establishments. And the Natchez Pilgrimage: The commercial exploitation of the beautiful old homes in and near the city, bringing thousands of visitors every year from all parts of the continent and from other continents, has in a real sense put Natchez on the map, and served as an important source of revenue as well. The recent opening of the Natchez-Vidalia bridge has been and will continue to be of great benefit to the city. The present-day Natchez is a city of some 15,296 people,[1] of attractive homes in the better residence districts, churches of several denominations, and a number of school buildings and public buildings, among which the high school and the new Auditorium deserve special mention.

A few villages are scattered over Adams County. Washington, at the junction of U. S. Highways 61 and 84, is interesting chiefly as the site of the one-time capital of the state and of the Jefferson Military Academy, the oldest military school for boys in the South. Selma and Stanton, northeast of Washington along Highway 61 and the Illinois Central Railroad, are railroad stops. Fenwick, Cranfield, and Leesdale are villages on the Mississippi Central Railroad southeast of Washington. Kingston, Sibley, Beverly, and Glendale are farm villages in the southern part of the county, and general stores are scattered over the county, chiefly at cross roads.

Adams County is served by a gas pipe-line and by two electric power lines (Plate 1). The Interstate Natural Gas Company 22-inch high pressure pipe-line is laid across the county from a point 3 miles southwest of Natchez to the southeastern corner of the county; the Mississippi Power and Light Company 110 Kv. line also crosses northwest-southeast, a few miles east of the pipe-line; and the Rural Electrification Administration power line and several branches serve the western and northern districts.[22]

PHYSIOGRAPHY

PROVINCES

Adams County includes parts of three physiographic provinces of Mississippi: (1) The Mississippi Alluvial Plain, represented by four areas at the foot of the river bluffs; (2) The Loess or Bluff Hills, a broad hill belt extending northeast-southwest the length of the county, and west-east from the west face of the river bluffs to Sandy Creek; (3) The Long Leaf Pine Hills, which include the southeastern corner of the county, east of Sandy Creek.[4]

TOPOGRAPHY

The surface of the alluvial plains is not altogether flat, but of low relief, due to uneven deposition by flood waters and to abandoned distributaries. Its regional slope is down stream and away from the main channels.

In the Loess or Bluff Hills physiographic province, which includes more than half of Adams County, the most prominent surface features are the elevations and depressions which have been shaped by and from the loess. This is especially true of the western part

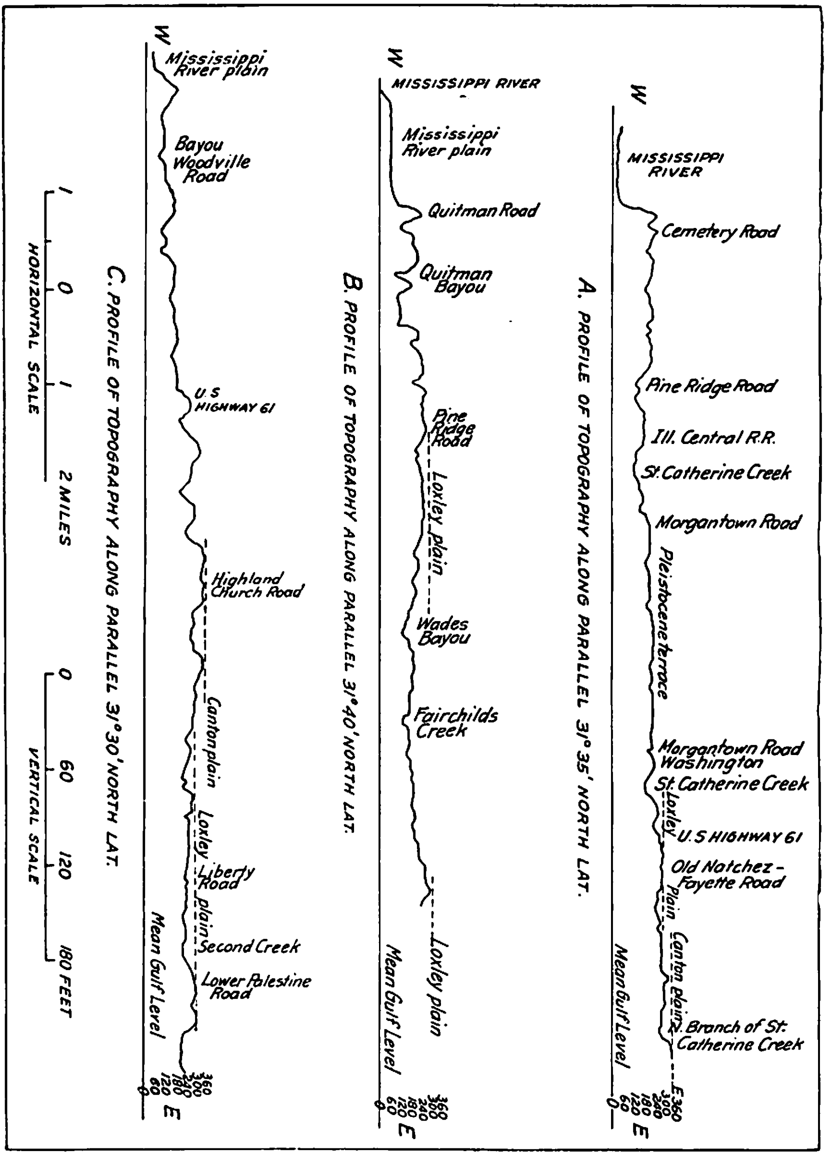

Figure 2.—Profiles of Adams County topography.

of the province bordering the Mississippi, which is a thickly loess-mantled, intricately stream-dissected belt of relatively great relief in short distances. Here is a splendid example of loess topography, a type of surface which has done much to give the Natchez region the picturesque scenery for which it is famous (Fig. 3).

A loess topography has certain characteristics which distinguish it from any other type of topography, its main features being steep-sided hills, deep steep-walled valleys, and vertical or sub-vertical scarps. Highways in loess country extend through a series of narrow cuts opening into the valleys; and some of the older local roads are trenches through the greater part of their length (Fig. 3). A special feature of the topography of this region, most conspicuous in the face of the river bluff, is a number of huge deep hollows or vertical-walled coves, formed by sub-aerial erosion working in conjunction with ground-water sapping of the underlying sands, producing land slips. At least one of these, "The Devil's Punch Bowl," has recently been well advertised locally.

Farther east, where the loess is thinner, the topographic forms, determined largely by the sands and gravels and to a lesser degree by the older formations, lack the sharpness of outline of the loess landscape. Although no well-defined boundary exists between the typical loess topography of the western part of the county and the less precipitous eastern districts, in general there is a lessening of relief towards the east and a smoothing of the gradation profile.

Of the scattered areas of the county where the loess is absent or very thin, the largest are in the southeastern part, east of Sandy Creek, and the northeastern corner, northeast of Coles Creek. The region east of Sandy Creek, included in Homochitto National Forest, is a maturely dissected terrane of sand, sandstone, small gravel, and a little loess and clay.

Adams County is within the area included by Matson's Sardis, Canton, and Loxley plains. Matson[3] states that the material underlying all of them has been much dissected, and only remnants of the plains remain as small isolated nearly level areas or as roughly even tops of divides. The maximum elevation of the Sardis plain east of Natchez is given as about 417 to 455 feet; of the Canton plain, 337 to 380 feet, and of the Loxley plain 320 feet (Fig. 2).

In many parts of the county Pleistocene or Recent stream terraces modify the topography. Excellent examples exist along the principal streams, notably along Sandy Creek, St. Catherine Creek, and Fairchilds Creek.

Except for the stream flats, the Adams County area as a whole may be described as hilly, the loess type of topography predominating. The regional slope is southward and southwestward, but the northeastern corner descends towards the northeast and north, and the northern part slopes northward and northwestward.

Figure 3.—Loess topography, Liberty Road west of Roseland Church, Secs. 4, 19, 21, T.6 N., R.2 W. July 18, 1941.

DRAINAGE

All the Adams County precipitation run-off goes to Mississippi River, either directly or indirectly, but by far the greater part reaches the Mississippi via three principal water courses: Homochitto River, St. Catherine Creek, and Coles Creek. The Homochitto, which flows into the Mississippi some 45 river miles below Natchez,[2] drains the southern half of the county through its two large tributaries, Sandy Creek and Second Creek, and a number of smaller streams. The St. Catherine Creek System carries the run-off of the north-central part of the county, and the Coles Creek System that of the northeastern and northern parts, mainly through its large tributary, Fairchilds Creek.

Due to the relatively heavy rainfall of Adams County, 50 inches or more per year,[3] the stream flow is considerable, although the very pervious materials of the uppermost formations, and the luxuriant plant growth including extensive forests and woodland, absorb much of the precipitation and thus restrict and retard the run-off. Few of the stream channels have surface flow throughout their lengths except during and shortly after heavy rains, and numerous smaller water-courses have no flow at all except at such times. Commonly the channels are choked with sand, silt and gravel, through and beneath which the water finds its way as underflow. Springs, present in all parts of the county where the sand and gravel crop out, and numerous in a few localities, feed many stream channels continuously, producing underflow chiefly. The outstanding examples of springs are along the Miocene-Citronelle contact, particularly at the base of Mississippi River valley bluff. In the course of his reconnaissance along this bluff from the northern boundary of the county almost to the southern during a time of extremely low river level, the writer found an almost unbroken line of springs and seeps. Many of the springs gave rise to strong streams of clear cold water which had cut deep channels in the alluvium and underlying clay leading to the river. Numbers of wells in this part of the state draw their water from the lower gravel horizon (Citronelle).[4]

ELEVATION AND RELIEF

The maximum relief of Adams County exceeds 440 feet. The lowest point is, obviously, at the southwestern corner, near where Homochitto River enters the Mississippi; the elevation here is not more than 15 to 20 feet above mean Gulf level. The highest point of the county is somewhere on the divide between the basins of St. Catherine Creek and Coles Creek on the north, and Second Creek and Sandy Creek on the south. Considerable areas on the crest of this ridge exceed 400 feet above datum, and some small tracts are between 440 and 460. The northwestern part of the county, which is most rugged, has a maximum relief of more than 250 feet.

STRATIGRAPHY

The rocks in Adams County consist of six geologic formations, the age and content of which may be summarized in tabular form.

GENERALIZED SECTION OF ROCK UNITS EXPOSED IN ADAMS COUNTY

	Feet
Psychozoic group	
Holocene system	
Recent formation	
Mantle rock, including soil and subsoil, talus, colluvium, etc.; alluvium, including stream channel materials and terraces; all a mixture of silt, sand, gravel, and clay	200
Unconformity	
Cenozoic group	
Pleistocene system	
Iowan series	
Loess formation	
Silt, commonly dark-brown to light-brown or light-yellow, but may consist in places of a basal bluish-gray unoxidized phase, a typical light-brown well oxidized phase, and an uppermost oxidized and leached phase; massive; contains lime concretions and shells of land snails, especially in middle phase; also scattered bones of Pleistocene mammals	92
Unconformity	
Nebraskan or Aftonian series	
Natchez formation	
Sand, gravel, and clay or clay shale: The sand is chiefly fine and prominently cross-laminated, gray or various shades of brown; the gravel is of various sizes, but chiefly small, the greater part of it chert, but some igneous pebbles and many highly-polished pebbles; lenses, lentils, or stringers; the clay or clay shale is generally sandy and in the form of lenses or lentils. Sandstone concretions are numerous in places	100
Unconformity	
Pliocene system	
Citronelle formation	
Gravel, conglomerate, sand, sandstone, clay: The gravel ranges in size from bowlders and cobbles to small pebbles and grit, chiefly chert, but a considerable percentage of quartz, especially among the smaller pebbles; cemented locally to conglomerate; the sand may be white or light-gray, but commonly is ferruginous, coarse to fine, and cross-bedded; locally cemented to sandstone. The clay is gray or iron-stained, and in pockets, lenses, or lentils	50
Unconformity	
Miocene system	
Pascagoula formation	
Clay, clay shale, sand, sandstone, and silt. The clay and clay shale are gray or mottled, blue to greenish, sandy, and locally lignitic; the sand and sandstone are silty	200
Unconformity	
Hattiesburg formation	
Clay, claystone or mudstone, sand, sandstone, blue and gray, or mottled, yellowish; thick beds of massive blue to greenish clays; marine in part, but locally lignitic	450

THE HATTIESBURG FORMATION

The Hattiesburg formation, referred to by some writers as "Hattiesburg clay," is described in one report as consisting chiefly of marine blue and gray clay, of which some beds are indurated to claystone or mudstone, many of the clay strata being sandy, and some sand interbedded with the clay. It is added that the clay "weathers to mottled red or yellow and finally to deep red or yellow when exposed at the surface," and that it contains some lignite and fossil

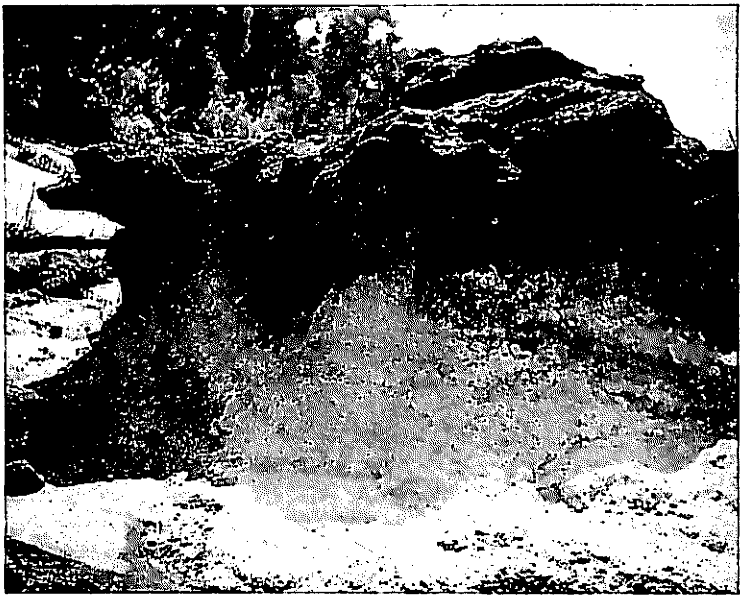

Figure 4.—Hattiesburg-Citronelle contact, bed of Mississippi River at east end of Natchez-Vidalia bridge. August 26, 1939.

leaves. According to the same authority, the formation has a thickness of 450 feet in the western part of Mississippi, dips south 15 to 20 feet to the mile, and is conformable with the underlying Catahoula sandstone, but unconformable with the overlying Pascagoula clay or the Citronelle or Pleistocene formations.[4]

Foster[5] gives an excellent summary, in the forms of discussion and correlation chart, of the history of the study and classification of the Miocene formations of the Gulf coastal region. He describes the Hattiesburg of the type locality (bluffs of Leaf River at Hattiesburg) as "thick beds of massive clays—150 or 200 feet thick—which contain some lime but very little sand," and gives the color of this typical Hattiesburg clay as "blue at or near the surface and light chocolate in the deeper test holes." He states further, "Wells in the vicinity of Hattiesburg and outcrops in the extreme northeastern corner of the county [Forrest]—as well as outcrops in the adjacent parts of Jones County—show that this thick clay bed is underlain by interbedded sands and clays, the sands increasing in prominence and becoming gravelly toward the base."

The Hattiesburg is the oldest geologic unit of formational rank which crops out in Adams County. Within the limits of the county the Hattiesburg formation shows blue and gray claystone strata, dark-gray to light-gray clays mottled with red, yellow, and brown, blue to yellowish montmorillonitic clays, and lignitic clays. These various kinds of materials may be seen at the Hattiesburg outcrops in the county and have been encountered in wells and borings and in the shafts sunk for the piers of the Natchez-Vidalia bridge. The exposures are for the most part in the bottoms of the valleys and the lower zones of the valley walls, being particularly prominent at the base of the river bluffs, but showing also in the St. Catherine Creek drainage basin, in the valley of Coles Creek, and in the headwater part of Sandy Creek watershed. The features of the Hattiesburg strata appear from representative sections of which descriptions follow:

SECTION OF THE BED OF MISSISSIPPI RIVER AT PIER NO. 1, NATCHEZ-VIDALIA BRIDGE.

(CORE BORING IN DOWNSTREAM WELL OF PIER NO. 1)[6]

	Feet	Feet
Miocene system		
Hattiesburg formation		112.0
Clay, chiefly hard dark-bluish to dark-greenish very fine-grained, containing fine sand; dries light-gray to yellowish; some layers break with hackly or conchoidal fracture, and have a smooth, soapy feel, resembling that of bentonite. To top of outcrop, about 27 feet above mean Gulf level	7.0	
Clay, dense sandy; sand, clayey; sandstone, fine-grained; all of prevailing bluish to greenish or bluish-green color when fresh, but softening and becoming light-gray to whitish or light-yellow when exposed to the air (Description of interval is based on material taken from excavation begun at surface of river bed, approximately 20 feet above mean Gulf level)	56.0	
Material not described, but without doubt similar to material above and below. (Wash boring, started at elevation 36.0 below mean Gulf level)	14.0	

Clay, sandy blue hard cemented; more clay than sand; similar to medium firm shale. (Core boring)	7.0
Sand, clayey, but almost all sand; hard blue cemented, similar to hard sandstone; fractures like rock when broken. (Core borings)	2.0
Clay, sandy; mostly clay; hard cemented blue, similar to medium firm shale (Core boring) to bottom of boring, elevation around 85 feet below mean Gulf level	26.0

It will be noted from the section that the rock penetrated by the drill was sandy clay, clayey sand, and sandstone, all blue, and all indurated to a degree which caused it to resemble "medium firm shale" or "hard sandstone" which "fractures like rock when broken."

The surface of the river bed all around the site of Pier No. 1 was well exposed during the summer and fall of 1939, at which time the river reached an extremely low stage. A marginal strip more than 100 yards wide measured from the water to the willows which mark the position of the river's edge at times of normal water, extended from a short distance up stream from the pier to perhaps 0.3 mile down stream from it. This exposure of the Hattiesburg presented a very uneven, pockety and lumpy surface, of which the highest point was 9 feet above river level (Fig. 4).

SECTION OF THE BED OF MISSISSIPPI RIVER IN THE WALLS OF THE UPSTREAM CENTER EAST WELL OF PIER NO. 2, NATCHEZ-VIDALIA BRIDGE

	Feet	Feet
Miocene system		
Hattiesburg formation		81.5
Excavated material from surface of river bottom, elevation 72.0 feet below mean Gulf level to elevation 73.0 feet below mean Gulf level	1.0	
Clay and sand mixture (probably); material too soft to core	4.0	
Clay, sandy blue hard firmly cemented	1.5	
Clay, sandy, mostly clay, similar to medium firm shale; hard blue firmly cemented	30.5	
Sand, very fine; probably residue from plastic mixture of clay and sand from which clay washed out in coring operation; too soft to core	5.5	
Sand, clayey, but mostly sand, cemented hard blue; similar to fairly hard shale	4.0	
Sand, very fine, as in 5.5-foot interval; too soft to core	3.0	
Clay, sandy, but mostly clay, hard blue cemented; similar to medium firm shale	23.0	

Sand, clayey, but mostly sand, hard blue cemented; alternating as beds with layers not sufficiently cohesive to core (upper 2.5 feet) which showed fine sand on washing, and which probably were either plastic clay and sand, in which the clay washed out, or loose, hard-packed sand	7.5
Clay, sandy hard blue cemented; mostly clay, similar to 23-foot interval; medium firm shale to bottom of boring; elevation 153.5 feet below mean Gulf level	1.5

SECTION OF THE BED OF MISSISSIPPI RIVER IN THE WALLS OF THE DOWNSTREAM CENTER WELL OF PIER NO. 3

	Feet	Feet
Miocene system		
Hattiesburg formation		64.0
Material excavated; from elevation 95.0 to 111.0 below mean Gulf level	16.0	
Sand, clayey, but mostly sand, hard blue cemented, similar to fairly hard shale	2.0	
Material too soft to core; drill sank of its own weight	3.5	
Clay, sandy, but mostly hard blue similar to medium firm shale; alternating with plastic layers of predominantly blue clay; alternate hard and plastic layers averaged 6 to 8 inches each in thickness	3.0	
Clay, sandy, but mostly clay; hard cemented blue, similar to medium firm shale	24.5	
Clay, blue plastic, and some hard particles	1.0	
Clay, sandy, but mostly clay; hard blue cemented; similar to medium firm shale	1.5	
Material not firm enough to core; drill sank of its own weight. Washed sample showed fine sand. Probably a plastic mixture of clay and sand, from which the clay washed out in the coring operation	10.5	
Clay, sandy, but mostly clay; hard blue cemented, similar to medium firm shale; to bottom of boring, elevation 159.0 feet below mean Gulf level	2.0	

The log summarized above bore the note that the engineers expressed varying opinions concerning the classification of the hard materials encountered by the borings, some preferring to call them shale, others sandy clay. The note continues: "The characteristics of all the hard strata are similar in that the materials are a combination of blue clay and fine sand in varying proportions. Where the sand predominates the material is harder and more brittle, and fractures like sandstone. Where the clay predominates the material is firm and tough as well as hard. Any of this material would stand with a vertical surface exposed without sloughing off."

The log of the well of the Natchez Ice Company, near by, gives no definite information concerning the Hattiesburg, but merely records a succession of clay and sand through a total thickness of 444 feet. The uppermost 203 feet of strata are designated "hard clay."[4]

During the low-water period, the up-dip parts of some of the Hattiesburg strata were exposed in several other places along the eastern shore of the river:

Below the foot of Franklin Street and between Franklin and Jefferson Streets, the Hattiesburg clay showed for a distance of around 700 feet, its top descending southward at a low angle. Here the clay is green, yellowish, and blue, jointed, and somewhat indurated. It is overlain by a gravel conglomerate (Citronelle) which is 3 feet thick in places and mixed with some coarse ferruginous cross-laminated gritty sandstone.

At the south end of Learned's lumber yard, above the mouth of a small bayou, Hattiesburg beds and overlying coarse conglomerate and ferruginous cross-bedded coarse-grained sandstone showed the same relations and characteristics as at the bridge.

Farther north, about west of the City Cemetery, the top of the clay overlain by conglomerate, showed 15 feet above river level.

One-fourth mile north of this point the clay could be seen to a height of 30 feet above the level of the river. The conglomerate bed overlay it here, too.

The farthest north of any considerable outcrop of the Hattiesburg at the base of the river bluffs, although slight showings were observed still farther upstream,* was some 100 yards north of the transmission line crossing (Sec. 10, T.8 N., R.3 W.), which in turn is about 0.3 mile above the property of the U. S. Loess Deposit. The exposure here was more than 100 yards long, and reached 5 feet above river level. As at the other river outcrops, the clay was capped with conglomerate and ferruginous sandstone.

Except at the base of the river bluff, outcrops of positively identifiable Hattiesburg beds are few in Adams County. Showings doubtfully assigned to the Hattiesburg appear, in the bluff section of Fairchilds Creek; along Hightower Creek the northernmost tribu-

* Notably at the southern tip of the wide strip of river flood-plain which forms the northern tip of the county.

tary of St. Catherine; and in a few places along the main St. Catherine Creek and the lower reaches of tributaries, notably Clear Creek and Melvin Bayou. The material is mainly blue or bluish-gray rust-spotted sand, but includes some light-blue to light-green clay, chocolate-brown clay, and yellow clay. The logs of holes along these streams show intervals of the materials named above, especially blue sand and clay.

The U. S. Geological Survey areal geology map of Mississippi indicates that Hattiesburg strata crop out along Coles Creek.[4] The present survey found in the valleys of small tributaries of Coles Creek a little west of the Adams-Franklin county line and north of U. S. Highway 84, outcrops of the massive blue to greenish "fullers earth" type of clay which features the upper Hattiesburg, and which is prominently exposed in upper Sandy Creek and tributaries. Farther down Coles Creek the material is chiefly blue and greenish brown-stained sand, much of which may have been re-worked and could have been derived from higher Pascagoula beds. In the channel of Whitens Creek, the main Adams County tributary of Coles Creek, small outcrops of the blue clay and sand and mottled clay are considered evidence that Hattiesburg beds lie subjacent to the loess and sand and gravel from the mouth of the creek upstream to or above the mouth of Walker Springs branch (Sec. 8, T.7 N., R.1 W.).

Conditions similar to those of Coles Creek exist in upper St. Catherine and headwater tributaries, and, in fact, through much of the length of the creek. From the presence of brownish-gray to greenish-gray and blue sand, blue clay, and particularly a rather persistent interval of a black sandy clay or clayey sand containing marcasite concretions and lignitized wood, the Hattiesburg is thought to be very near the surface in the channels of these streams.

Kittering Creek, a tributary which flows west almost along the strike of the beds and enters St. Catherine in Sec. 75, T.7 N., R.2 W., has exposed, in addition to material doubtfully assigned to the Hattiesburg, strata which include the Hattiesburg-Pascagoula contact (Sec. 77, T.7 N., R.2 W.). This stratigraphic section is in the south wall of the creek channel, some 0.4 mile above the mouth of Windy Hill Manor Creek. Here the lowest member of the section is a jointed clay, greenish where exposed, blue where fresh, much like that which crops out in upper Sandy Creek. Above it lies a sandy, lignitic clay which contains lignitized wood and numerous concretions of marcasite (Fig. 5). The formational contact is thought to be at the top of this lignitic layer. The same contact appears to crop out some 2 miles farther down the creek, where blue sand shows at a lower level under the Pascagoula gray sand.

The headwater branches of Sandy Creek and the upper main creek for a distance of 3 to 4 miles have created the finest exposures of the Miocene strata to be found in Adams County. Sections are described in the discussion of the Pascagoula formation. The lowest member of the sections is assigned to the Hattiesburg. The Hattiesburg material in this region is typical "fullers earth" clay—dense

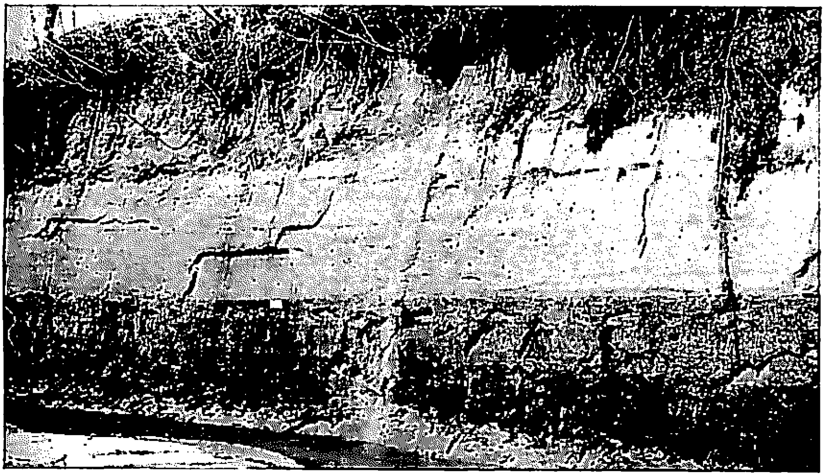

Figure 5.—Hattiesburg-Pascagoula contact, Kittering Creek, Sec. 77, T.7 N., R.2 W. Photo by W. C. Morse, March 14, 1942.

jointed clay, light-blue on a fresh fracture surface, olive drab to pale greenish or greenish-gray to brown where weathered and iron oxidized; it is slightly lignitic along the numerous joint planes, slickensided, splotched with brown iron oxide in places, and contains a little very fine sand. The upper part is markedly lignitic. The contact with the overlying bed is marked by a brown crust or band of iron oxide-cemented sand, and rusty patches in the clay; also it is topographically irregular. This blue clay bed is excellently exposed in the floor and basal zones of the channel walls of a headwater tributary of Sandy Creek west and southwest of Sunnyside plantation house, the Everett Ratcliff home (Secs. 51 and 68, T.7 N., R.1 W.). It crops out almost uninterruptedly throughout the lowermost 0.5 mile of this branch, and discontinuously for 2 miles or more down the main Sandy Creek below the mouth of the tributary. It shows, also, in a branch of Sandy Creek a little east of the Ratcliff residence; but the best exposures of this massive blue clay are along the channel of upper Sandy Creek a few rods west of the Adams-Franklin county line. At the upper end of the series of outcrops, the clay forms the floor and the lower part of the walls of the creek channel for 60 yards, and is overlain above an uneven contact by a greenish-gray cross-bedded, wavy-bedded limonite-spotted sand which is thought to be basal Pascagoula. In another place or two a lignitic sand bed

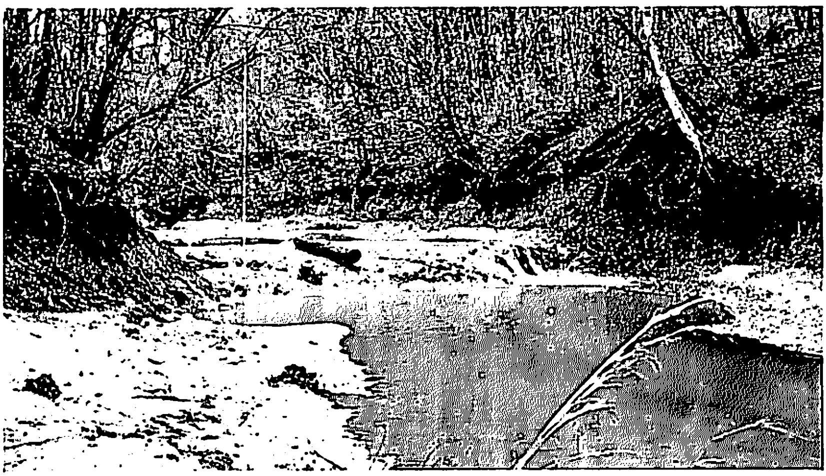

Figure 6.—Top of Hattiesburg formation, upper Sandy Creek, Sec. 72, T.7 N., R.1 W. Photo by W. C. Morse, March 12, 1942.

containing much lignitized wood lies on the blue clay, forming a basal layer of sand. Near the mouth of a small northern tributary, some 300 yards farther down, gray, red-mottled, and yellow-mottled jointed clay forms the floor and lower parts of the walls of Sandy Creek for 100 yards. A harder layer, more highly oxidized, yellow to red-brown on the surface, forms a ledge 2.5 feet high over which the water falls (Fig. 6). The clay is bright blue on a fresh fracture surface. A feature of the yellow harder layer is dense concretions, roughly rounded or sub-spherical for the most part, very light-blue or light-gray, and very fine-grained. They appear to be impure iron carbonate, oxidized to limonite on or near the surface.

Sandy Creek apparently has established its channel in this dense massive blue rust-spotted clay, near the top, through almost the upper half of its course, and has developed a gradient a little lower than the degree of southward dip of the underlying strata (Fig. 13). In the left wall of the creek channel, 92 yards below and S. 20° E. from the mouth of the western Sunnyside tributary, a thickness of 8.9 feet of the blue clay shows above the water-level of the creek—the greatest thickness exposed in the county with the exception of the county line outcrop. It is overlain by 8.5 feet of fine blue and gray sand (Pascagoula). Down stream the clay beds crop out for a distance of about 2 miles, but the greatest thickness exposed is 5 feet, in the right bank 100 yards below the Cranfield-National Forest public road bridge, on the Lee Ratcliff property. At this point the basal several inches to a foot of the overlying fine gray bedded sand include masses of re-worked clay, a feature here of the Hattiesburg-Pascagoula contact. The sand above this middle zone is in places worked into it, and the contact between clay and sand is sinuous. A hole, started at the top of the bank above this outcrop and continued to creek level or below, penetrated under the thin loess interval 17.5 feet of sand, 3.5 feet of light-brown clay, and 6.4 feet of light-blue clay.

It is pertinent to note here that the top of this massive clay terrane is consistently uneven, and in the whole series of outcrops along upper Sandy Creek and its tributaries the uppermost 1 foot or so of the clay is consistently lignitic, pieces of lignitized wood showing in a few places. Where an overlying bed is present the contact of the two is irregular.

In the channel of Sandy Creek the "fullers earth" clay dips below water-level (Sec. 3, T.6 N., R.1 W.), about 100 yards above the junction of a right tributary, but this tributary and a nearby smaller one have exposed it toward their lower ends. About 0.4 mile above the mouth of the larger of these branches, several feet of gray mottled clay crop out below a fine greenish-gray sand. A little farther up, a bed of black closely-jointed lignitic sandy clay is exposed in the right bank, and 0.4 mile still farther up stream (north) it appears as a 4-foot to 5-foot brown and black sandy clay. The top of the black bed has been eroded, and the resulting depression filled with a clay shale which overlies it. At this contact the bedding is very contorted. Although the gray mottled clay can not be traced directly into the black clay or either of them into the dense blue "fullers earth" clay which shows in Sandy Creek, the three are thought to be phases of the same unit, on the basis of relative elevations and stratigraphic relations.

The top of the Hattiesburg is well exposed in places along a sizeable tributary of upper Sandy Creek which rises in western Franklin County, flows in general southwest, and joins the main creek in Sec. 24, T.6 N., R.1 W. (see section in discussion of Pascagoula formation). The clay here, as elsewhere, is dense, sky-blue where fresh, but greenish on exposed surface; it is closely jointed, and its lumps are slickensided. The beds form rapids and falls here. No outcrop of the Hattiesburg was seen along Sandy Creek below the mouth of the tributary.

THE HATTIESBURG-PASCAGOULA CONTACT

Foster[5] found that in Forrest County "The contact between the two Miocene formations (Hattiesburg and Pascagoula) is either covered or gradational and so obscure that it could not be definitely located." Although a like statement concerning the contact between the same two formations in Adams County would be true in general, in a few places this contact is more or less definite, and characterized by evidences of unconformity, if the stratigraphic position accepted by the present survey for the boundary is the true one. A recapitulation of the contact features may be worth while. The top of the Hattiesburg is thought to be the upper surface of the massive blue clay of the Sandy Creek sections. Almost everywhere it shows, the contact of this clay with the overlying beds is irregular; the upper part of the clay may be marked with rusty patches, and a brown crust or band of iron oxide-cemented sand may define the actual plane of contact. Moreover, the uppermost 1 foot or so of the massive blue clay is consistently lignitic, and contains lignitized wood and iron sulphide concretions in several places. The hard roughly rounded bodies in the most eastern of the Sandy Creek outcrops; the presence in the basal part of the overlying sand of masses of re-worked clay; and sand-filled depressions in the clay—all would seem to be features of an unconformable contact. In short, evidence seems to exist in Adams County of unconformity between the Hattiesburg and Pascagoula formations, and the contact is reasonably sharp in a number of outcrops.

THE PASCAGOULA FORMATION

The Pascagoula formation is named from Pascagoula River, in southeast Mississippi, where there are prominent exposures of beds typical of this geologic unit.

The Pascagoula materials are classified in the literature as clay, sandy clay, fine sand, and silty sand. Some of the clay, the chief kind of material, is indurated to claystone, and much is sandy. Layers of silty sand and fine sand, some indurated to sandstone, are interbedded with the clay. The formation is said to have a total thickness of 400 feet in the western part of the state; the strata to dip slightly west of south at an average degree of 30 feet to the mile near Mississippi River. The Pascagoula lies unconformably on the Hattiesburg and beneath the Citronelle.[4] Lowe[7] refers to bluish and greenish clays of the Pascagoula, in some places containing marine and estuarine fossils, in the southeastern part of Mississippi. Foster[5] states that the outcrops along the Pascagoula and Leaf Rivers, in southern Mississippi, show interbedded sands, silts, and sandy clays. . . . The color approaches sky blue and commonly has a somewhat greenish tint. The clays are more sandy than those of the Hattiesburg formation, and relatively thick beds of sand are not uncommon.

The Pascagoula is the middle of the three Tertiary formations which crop out in Adams County.

As has been stated, the Hattiesburg-Pascagoula contact is thought by the writer to lie at the top of the massive blue to greenish "fullers earth" clay which crops out at several places in the county. This contact, well defined and sharp in a few places, is obscure in many others. Bodies of light-gray to dark-gray clay or sand, mottled with red, yellow, purple, brown, or pink iron oxide, are present almost everywhere the contact zone shows. As will appear from the descriptions of sections and the records of borings, in some places the mottled material grades into the blue dense massive clays assigned to the Hattiesburg, and into Pascagoula beds in other places. Thus the field evidence seems to indicate that some of these bodies could properly be assigned to the Hattiesburg, others to the Pascagoula, and that still others are products of the weathering of both formations, along with some material from the terrace sands and clays. Possibly much of this mass of partly oxidized mineral matter, or partly leached, as the case may be, accumulated as a residuum from the massive blue clays of the Hattiesburg during the post-Hattiesburg pre-Pascagoula interval, and great volumes of it were swept away in early Pascagoula time and incorporated in the lower beds of the younger formation. However, a large part of the mottled clays and sands now at the surface no doubt represents Hattiesburg and Pascagoula strata, along with some Citronelle and younger materials weathered throughout the time since they were first exposed.

Descriptions of typical outcrops and sections will indicate the characteristics and relationships of the Pascagoula strata.

Pascagoula material is believed to have been penetrated in borings as far north as upper Hightower Creek (G118, Sec. 14, T.7 N., R.1 W.). The farthest north outcrop found, in a tributary of Whitens Creek (Sec. 13 ?, T.7 N., R.1 W.), shows gray, red-mottled sandy clay capped by a 2-foot to 3-foot dull white silty sandstone.

Figure 7.—Lower Pascagoula strata, upper fall, Whitens Creek, Sec. 42, T.7 N., R.1 W. Photo by W. C. Morse, March 13, 1942.

In Whitens Creek, the indurated beds of the lower Pascagoula condition two small water falls with rapids between and above (Fig. 7).

Section of floor and right wall of Whitens Creek channel about 1 mile northeast of junction of U. S. Highway 84 and Stanton-Fenwick road (Sec. 42, T.7 N., R.1 W.)

	Feet	Feet
Holocene system		
Recent formation		0.5
Soil, light-brown silt loam (colluvial) at top of exposure and foot of slope	0.5	
Miocene system		
Pascagoula formation		22.7
Clay, yellow very plastic; no sand	0.5	

Clay, light-gray to olive-drab and rusty light-brown; somewhat lignitic, bedded	9.5
Sandstone, light-gray to dull white, but somewhat mottled with red and brown; blue where fresh; silty, very fine-grained; indurated layer at top 0.8 foot thick forms rapids	6.5
Sandstone, hard silty layer, similar to above; forms waterfall with clay below	1.4
Clay, very sandy, or sand, silty and clayey, light bluish-gray where fresh, and light-gray, faintly greenish, on exposed surface; mottled with spots of brown, reddish, and wine-colored rust; closely jointed, and checked on weathered surface; hard; vertical or steeply sloping face; to bottom of pool below lower waterfall	4.8

The strata are also well exposed elsewhere in Whitens Creek channel and tributaries, indicating a thickness of probably 50 feet or more of indurated and semi-indurated beds present in this locality.

Red-mottled, gray sandy clay and clayey sand similar to that described, with some beds of light-blue to pale-green fine silty sand crop out in every considerable tributary of St. Catherine Creek, except the northernmost, almost as far west as the U. S. Highway 61 bridge over the creek southeast of Natchez, and south nearly to the head of Solitary Valley Creek. Such materials are prominent towards the head of Sandy Creek, also, and in the tributaries of upper Sandy Creek. The dull white silty sandstone interbedded with the clay is present at almost every outcrop, and can be followed from place to place over an area some 4 miles wide north-south and 12 miles long east-west. Neither clay nor sandstone was seen north of St. Catherine Creek basin, nor anywhere in the basin of Second Creek. Of the numerous good outcrops, two or three may be described.

SECTION OF LEFT WALL OF CHANNEL OF TRIBUTARY OF ST. CATHERINE CREEK (SEC. 35, T.7 N., R.1 W.) 150 YARDS SOUTHEAST OF MAIN CREEK CHANNEL

	Feet	Feet
Holocene system		
Recent formation		4.0
Soil and subsoil, weathered yellowish clay	4.0	
Miocene system		
Pascagoula formation		29.0
Sandstone, light-gray to white very fine-grained indurated jointed; forms ledge which caps clay and causes steep wall of clay beneath; contact even; upper contact of sandstone not well defined, because covered by slumped material and plant growth. Large blocks of sandstone fall into creek	5.0	

Clay, light-gray to dark-gray closely jointed semi-indurated somewhat sandy massive; mottled with blood-red spots and streaks, especially towards top	23.5
Clay, massive sandy very light-gray; mottled with red; indurated; shows as floor of creek and slightly above water-level; channeled by water to water level of creek	0.5

The Pascagoula strata are well represented in the outcrops of Clear Creek, a southern tributary of St. Catherine, and its tributaries. Johnson Creek, a small tributary which enters Clear Creek about one-fourth mile below U. S. Highway 84 bridge over Clear Creek, and a ravine which joins Johnson Creek, have cut across beds described below.

SECTION OF JOHNSON CREEK AND TRIBUTARY (SECS. 46 AND 47, T.7 N., R.2 W.)

	Feet	Feet
Holocene system		
Recent formation		1.5
Soil, brown silt loam, and subsoil, brown clay loam to top of ridge; elevation 430 feet	1.5	
Pleistocene system		
Loess formation		80.0
Silt, light-brown massive, containing shells of land snails	80.0	
Natchez formation		.....
Doubtfully present; possibly masked by loess; red-brown interval at base of loess, sandy and clayey	.....	
Pliocene system		
Citronelle (?) formation		24.0
Sand, red-brown coarse; gravel, chert, coarse to fine. Cobbles 8 inches or more in diameter in float	24.0	
Miocene system		
Pascagoula formation		86.1
Clay, gray, similar to that of 10-foot interval. Mostly covered with sand, gravel, silt, and forest debris from above, but the gray clay shows here and there, especially near top; presumably the entire interval is gray clay. Yellow mottling, but less vivid than below	24.0	
Clay, light-gray plastic. Interval covered for most part by sand and gravel wash, but gray clay is exposed here and there. About 8 feet above the base of the interval, some 2 feet of grainy jointed plastic light-gray clay with carbonaceous matter and leaf impressions along joint-planes. Probably this interval and the next above should be considered one, but cover makes this impossible to determine	10.0	

Sand, silty very fine light-gray mottled with red and golden yellow iron oxide splotches and stains; more clayey and silty towards top; hard part of it indurated to a friable sandstone; breaks into angular lumps and joint blocks; iron oxide-cemented blocks are harder. Resembles interval next below, but iron "knots" are less prominent and do not form such a bumpy surface. Also more yellow and less red than in the interval below	8.0
Clay, very sandy and silty gray mottled; or mottled clayey and silty sand; rough, uneven surface; indurated cliff-forming ledge. Very similar to, possibly identical with, "Davion rock" of old writers	4.5
Clay, silty, and sand, silty and clayey gray mottled; very rough surface	3.0
Sandstone and clay; thin layers (3 to 4 inches) of clayey sandstone alternating with thin laminated shaly clay; mottled	1.7
Sandstone, dull white to very light-gray where fresh, but mottled and impregnated with red and yellow iron oxide on and near surface; very fine-grained; indurated to friable; massive, but weathers to thin beds; fossiliferous; contains numerous pelecypod molds of genus much like *Pleurobema;* fluviatile[10]	4.2
Clay, light-gray, red to purple mottled, laminated	0.7
Sandstone, white or very light-gray fine-grained indurated	0.7
Sandstone, fine silty, gray	1.3
Clay, purple and yellow mottled brittle sandy and silty	2.0
Clay, gray, mottled with purple and red and yellow	4.0
Sandstone, gray to olive drab and yellowish friable	2.0
Clay, yellow to brown stiff	4.0
Clay, mottled, light-gray to whitish	6.0
Clay, light-gray, a little sand	5.0
Sand, light-gray, slightly clayey very fine, bluish beneath surface	3.0
Sand, gray, very fine	2.0

The base of the section is 8 feet below the mouth of Johnson Branch and about level with the mouth of Clear Creek (elevation about 239 feet above mean Gulf level). The basal five intervals, from the log of a hole on the right bank of the creek 26 feet above its mouth, to 8 feet below the bed of Clear Creek, may be Hattiesburg.

SECTION OF NORTHEAST WALL OF CLEAR CREEK CHANNEL AT RAVINE 460 YARDS ABOVE U. S. HIGHWAY 84 BRIDGE OVER CLEAR CREEK (SEC. 47, T.7 N., R.2 W.)

	Feet	Feet
Holocene system		
Recent formation		2.0
Soil and subsoil, colluvium, brown loam	2.0	

Pleistocene system		
Loess formation		18.0
Silt, massive fine light-brown	18.0	
Miocene system		
Pascagoula formation		10.0
Sand, indurated clayey very fine; light-gray on weathered surface, darker gray where fresh; splotched with iron oxide stains; rough and lumpy weathered surface; top 3.5 feet form indurated cap, which thins to less than a foot at upper end of exposure; to creek floor about 1 foot below water-level	10.0	

The lowest member of this section probably is correlative with the 1.7, 3.0, and 4.5-foot intervals of the Johnson Creek section.

Strata of the section just described can be followed 125 yards farther upstream to a mass of sandstone some 250 feet long which has been trenched by the water, exposing a thickness of 10 feet. The upper part of the rock is ferruginous, but where there is no iron stain the sand is gray to olive drab. These beds are correlated with the 8.0-foot interval of the Johnson Creek section. Relative elevations and lithologic similarity suggest also that they may be correlative with beds of the Whitens Creek section and of the Kittering Creek section.

SECTION OF LEFT (SOUTH) WALL OF KITTERING CREEK CHANNEL 0.4 MILE ABOVE THE MOUTH OF WINDY HILL MANOR CREEK (SEC. 77, T.7 N., R.2 W.) (FIG. 5).

	Feet	Feet
Holocene system		
Recent formation		1.0
Soil, brown silt loam	1.0	
Miocene system		
Pascagoula formation		14.0
Clay, light-gray jointed sandy	6.0	
Sand, light-gray to greenish-gray, blue where fresh; fine, laminated	6.0	
Sand, lignitic; less lignitic and somewhat consolidated at upstream end of exposure	2.0	
Disconformity		
Hattiesburg formation		3.0
Clay, sandy lignitic, containing lignitized wood and numerous concretions of marcasite; black, but color leaches out and oxidation of marcasite gives rust stain	2.0	
Clay, jointed, greenish where exposed, blue where fresh; resembles that in river bed; makes up floor of creek and basal zone of wall, to floor of Kittering Creek channel	1.0	

LOG OF A BORING STARTED DIRECTLY ABOVE THIS OUTCROP ON THE CREST OF A LOW RIDGE

No.	Depth	Thick.	Description of strata
1	1.4	1.4	Loess
2	7.3	5.9	Clay, gray
3	9.0	1.7	Clay, brownish-gray
4	14.6	5.6	Clay, gray
5	21.0	6.4	Sand, gray fine, some clay
6	25.0	4.0	Clay, black; water
7	35.0	10.0	Clay, blue
8	42.8	7.8	Clay, gray, reddish mottled
9	51.0	8.2	Clay, gray

Intervals 2 to 5 inclusive are assigned to the Pascagoula; 6 to 9 to the Hattiesburg.

Figure 8.—Basal Pascagoula beds, gorge of tributary of upper Sandy Creek, E. Ratcliff property, Sec. 68, T.7 N., R.1 W. February 18, 1941.

Solitary Valley Creek, a tributary which enters St. Catherine Creek from the east (between Secs. 3 and 48, T.7 N., R.3 W.) about half way between Liberty Road and U. S. Highway 61, has cut into the Pascagoula beds for considerable distances. Along both the main stream and its upper southern tributary outcrops of the gray mottled clay and sand and of at least two sandstone or sand beds are numerous. In a place or two the gray mottled clay is the wall material to a height of 10 to 15 feet and the floor here and there for several rods uninterruptedly. These materials were penetrated in about 40 borings in these valleys (G36-52 inc.; G57; G89-95 inc.).

Sections of the Hattiesburg and Pascagoula formations are well exposed along upper Sandy Creek and its headwater branches and the Pascagoula in at least two places farther south along the main creek and a tributary. The section described below indicates their chief characteristics in the Sandy Creek region (Fig. 8):

SECTION OF HEADWATER TRIBUTARY OF SANDY CREEK, SOUTHWARDS FROM A POINT ON THE EVERETT RATCLIFF LAND ABOUT 0.5 MILE SOUTH OF U. S. HIGHWAY 84 (SECS. 51 AND 68, T.7 N., R.1 W.)

	Feet	Feet
Holocene system		
Recent formation		1.5
Soil, brown silt loam, and subsoil, silty clay, to level of U. S. Highway 84	1.5	
Pleistocene system		
Loess formation		9.0
Silt, brown fine, containing snail shells and lime concretions	9.0	
Pliocene system		
Citronelle formation		70.0
Sand and gravel, ferruginous and non-ferruginous cross-laminated; gravel small chiefly chert; some ferruginous sandstone and conglomerate	70.0	
Miocene system		38.4
Pascagoula formation		27.8
Clay shale, as below, but laminae more regular, and oxidation more pronounced; contains some sand pockets and lentils; gray iron-rusted	5.7	
Clay or clay shale, bluish to grayish; much fractured; streaked and mottled with iron oxide; outcrop shows dull white from limy material, chiefly concretions; bedding irregular; pockets and lentils of greenish-gray sand at various angles. Farther up stream this interval is not clearly separated from interval above	1.8	
Sand, greenish-gray, as below; top lignitic	0.7	
Sand, gray clayey; vertically jointed; breaks into blocks; probably limy; shows as white band in outcrop cliff; absent farther up stream	0.3	
Sand, greenish-gray, as below; laminated; some dark, more indurated patches in relief; combined with 0.7-foot interval up stream	1.5	

Clay shale, gray sandy; lime concretions and stringers abundant, forming a layer in places; sun-cracks; platy limy crusts	0.2	
Sand, greenish-gray, as below; upper 0.3-foot to 0.4-foot indurated and dark; hard limy masses in relief	1.6	
Clay shale, sandy, with lime concretions	0.1	
Sand, gray, as below; black in places farther up stream	0.4	
Clay shale, as below, but very sandy, approaching a shaly sand; numerous irregularly shaped lime concretions	0.4	
Sand, gray very fine; laminated horizontally, with discontinuous lentils and laminae of clay shale; blue to greenish-gray; uneven contacts, variable thickness	3.0	
Clay shale, as 1.4-foot interval, but sandier; hard flat lime concretions oriented with laminae	3.0	
Sand, very silty fine; blue where fresh, greenish to gray or light-brown on weathered surface; intricately laminated and cross-laminated; excellent ripples in sand. Bed very compact, and conspicuous in gorge wall; thickens down stream to 4.4 ft.	3.0	
Clay shale, finely laminated thinly bedded, blue to dove-gray or light-gray; sand and iron oxide along laminae and bedding-planes, especially at top; white nodules and sun cracks etched in iron rust; hackly fractures; surfaces of blocks very smooth; extremely fine-grained, and no sand except along planes; extremely jointed near surface; breaks out in smooth-surfaced blocks. Good horizon marker	1.4	
Silt or clay, silty; indurated blocks, dull white when dry; may be indurated top of 0.7-foot interval below. Irregular contact	1.0	
Clay, gray, with lignitic matter, lime lumps and grains and iron oxide; much mixed up; irregular contact	0.7	
Sand, blue, greenish-gray on surface	3.0	
The first three Pascagoula Intervals seem to pinch out up stream, and are absent in the gorge farther up.		
Hattiesburg Formation		10.6
Clay, greenish; contact with sand below marked by rust stain; much like first interval but darker, more lignitic. Rust aggregates, especially near top, and upper part very lignitic in places. Outcrop belt is distinct along the wall, because of dark color. Much jointed and slickensided	3.5	
Sand; gray to pale green on exposed surface, light-blue on fresh surface; blue is lighter than that of underlying clay. Very silty, perhaps as much a silt as a sand; iron rust spots at top. Clay-sand contact is irregular, the lower part of the sand forming a rusty band by which the contact can be traced. Pinches out upstream	3.5	

Clay; olive drab to pale greenish or greenish-gray to brown where weathered and iron oxidized, but light blue on freshly exposed surface; slightly lignitic along numerous joint planes, and as a whole splotched with brown iron oxide. Slickensided; dense; so-called "fullers earth." This bed can be followed along an almost unbroken outcrop upstream for 0.5 mile. The contact with the sand above is irregular and is marked by a brown band of iron rust spots; to level of Sandy Creek at mouth of tributary	3.6

A sub-parallel tributary of Sandy Creek about 0.5 mile east of the last section almost duplicates it, but the beds are not so well exposed.

SECTION OF LEFT WALL OF CHANNEL OF MAIN SANDY CREEK 92 YARDS BELOW THE MOUTH OF WESTERN SUNNYSIDE TRIBUTARY ALONG WHICH THE TYPE SECTION WAS MEASURED (SEC. 73, T.7 N., R.1 W.)

	Feet	Feet
Holocene system		
Recent formation		2.0
Soil and subsoil to top of exposure	2.0	
Miocene system		
Pascagoula formation		9.0
Clay shale (1.4-foot interval of Ratcliff branch section)	0.5	
Sand, fine blue and gray, marked by two distinct iron oxide bands toward the base	8.5	
Hattiesburg formation		8.9
Clay, blue dense "fullers earth" type to the level of Sandy Creek channel	8.9	

The silty sand of the Pascagoula appears here and there in the channel banks of Sandy Creek for three to four miles below the Ratcliff section, but the best showings are along three tributaries from the northwest and a larger one from the northeast, all entering within a distance of some five miles. In the largest of the northwest tributaries, which joins its main in Sec. 3, T.6 N., R.1 W., the lignitic zone that is thought to mark the Hattiesburg-Pascagoula contact is especially well exposed and is overlain by a fine greenish-gray sand.

The northeast tributary rises in western Franklin County, flows in general southwest, and enters Sandy Creek (Sec. 24, T.6 N., R.1 W.) a little south of the parallel of 31 degrees 30 minutes north latitude and some 2 miles west of the Adams-Franklin county line. About a mile and a half by the creek from the county line, the Miocene strata appear, and crop out almost uninterruptedly down stream almost to Sandy Creek, a distance of three miles.

SECTION OF LEFT TRIBUTARY OF UPPER SANDY CREEK FROM A POINT 0.3 MILE SOUTH OF FARMHOUSE ON MILLER AND WEBB LAND, AND 1.3 MILE FROM THE ADAMS COUNTY-FRANKLIN COUNTY LINE, TO MOUTH OF STREAM AT SANDY CREEK (SECS. 25 AND 24, T.6 N., R.1 W.)

	Feet	Feet
Miocene system		
Pascagoula formation		27.8
Clay, gray mottled with red, yellow and brown iron oxide spots; darker gray than first interval; in places uppermost 1 foot is black. Probably not interbedded with other strata, but largely weathered product of several outcropping strata	15.0	
Sand, fine gray laminated, with thin layers of gray clay toward base in places	0.8	
Clay shale, closely jointed laminated; upper 0.5-foot sandy shale; compact, very fine-grained; dove-colored or slate gray to blue where fresh, but iron stained on or near surface; contains numerous white chalky clay and iron carbonate concretions, and also nodules formed by iron cementation of minor structural patterns	2.3	
Sand, light gray very fine soft silty, to sandstone, fine-grained; projects into clay below along irregular contact; sandstone missing in places, and very uneven contact where sandstone is absent. Thickness 4 to 8 inches	0.5	
Clay, somewhat lignitic, slate-colored to black; sandy and silty; contains plant roots; oxidized and channeled at top; dark blue where fresh, but may be greenish on surface	1.2	
Sand, gray very fine laminated, contains some sinuous and cross-lamination; bedded; pale green or greenish-gray on surface in places. Indurated to a friable sandstone farther down stream, where it is light-gray and indurated at top which is dull white. In sandstone cross-lamination planes defined in places by cracks and stringers of clay	8.0	
Very irregular and uneven contact		
Hattiesburg formation		15.0
Clay, gray mottled with various shades of red, yellow, brown, and black iron oxide spots; very sandy up stream, a clayey and silty sand in places; purer farther down, where it is a bright sky-blue where fresh, but quickly turns green on exposure, and rusts readily. Closely jointed blocks slickensided—"fullers earth." Forms floor of creek, and conditions rapids and two falls	15.0	

In the walls of this branch a lateral succession of sand and clay strongly suggests a disconformity along which depressions in the clay have been filled with sand. It will be noticed from the respective sections that the thickness and lithologic features of the strata of the last section warrant the correlation of these beds with those of the Sandy Creek section a little below the mouth of Ratcliff branch.

Higher beds are exposed three miles farther south (Sec. 45, T.6 N., R.1 W.) about 0.4 mile northeast by east of the Carter Store, in the southeast wall of the valley of Sandy Creek. The feature here is 30 feet of brown to gray clay, which are overlain by 28.5 feet of Citronelle sand.

One of the best sections of Pascagoula beds in the county is some 2 miles still farther south.

SECTION OF SOUTHEAST WALL OF SANDY CREEK CHANNEL AT MOUTH OF O'FARRELL CREEK, (SEC. 51, T.6 N., R.1 W.)

	Feet	Feet
Holocene system		
Recent formation		1.0
Soil, silt and sandy loam, brown, to top of cliff face, about 100 feet above water	1.0	
Pleistocene system		
Loess formation		12.0
Silt, light-brown	12.0	
Miocene system		
Pascagoula formation		56.0
Clay, light-gray to whitish, very plastic, somewhat iron-mottled, slickensided	2.0	
Sand, light-gray, lumpy, very fine, somewhat indurated, especially near top. Contact rusty	5.0	
Clay, light-gray to pale greenish-gray, rust-spotted, very rusty in places, to dark-gray; lumpy, slightly indurated, lumps slickensided; forms dark belt across face of cliff	13.0	
Sand, light-gray to pale green or olive drab very fine; shaly through much of the thickness; contains sufficient clayey or silty material to give it a shaly structure, the thin shaly layers alternating with the sand; thin interval at bottom nearly black. Forms light-gray to bluish belt across face of cliff. Rusty contact	10.0	
Clay, light-gray, much jointed; slickensided along block surfaces; rusty, sandy, lumpy. Shows as light-brown belt across face of cliff	6.0	
Sand, light-gray to pale green or yellowish; very fine	4.0	
Rusty contact		
Clay, sandy, to sand, clayey; pale gray to whitish; rusty spots and streaks	8.0	
Clay and sand: alternating thin layers of rusty gray sand and bluish-gray clay; laminae etched and defined by iron rust; some hard crusts of ferruginous clay or sand; thin purple laminae	6.5	

Sand, dull white, coarse	1.0	
Shale, almost completely covered	0.5	
Covered, talus slope of clay and sand, to water level of Sandy Creek		25.0

The farthest south outcrop of the county which very doubtfully might be assigned to the Pascagoula is the lower part of the south wall of a cut for Hutchins Landing Road, between Lamberts Bayou and Lynn Creek (Sec. 16, T.5 N., R.2 W.).

SECTION OF THE SOUTH WALL OF A CUT FOR HUTCHINS LANDING ROAD

	Feet	Feet
Pleistocene system		
Loess formation		15.0
Loess, sandy iron stained	15.0	
Miocene system		
Pascagoula formation ?		5.6
Clay, light gray, somewhat lignitic, only slightly sandy	3.0	
Sand, clayey dark brown to black lignitic	0.6	
Sand, fine bluish gray compact, to bottom of roadside ditch	2.0	

THE CITRONELLE FORMATION

Lying on the Hattiesburg and Pascagoula formations of Adams County is a relatively thick body of sand, gravel, and clay which commonly is designated on geologic maps and in geologic reports as Citronelle of Pliocene age and Natchez of Pleistocene age.

The Citronelle formation was so named by G. C. Matson[3] and described in detail by him. The salient features of the Citronelle as stated by Matson are:

The formation, named from Citronelle, Alabama, because of the excellent exposures in that vicinity, is a body of Pliocene sands, gravels and clays spread as a broken belt of varying width along the seaward margin of the Gulf coastal states a little north of the Gulf from western Florida to eastern Texas. The belt is widest a few miles east of Mississippi River, and narrows east and west from there. The Citronelle lies unconformably on the Pascagoula (Miocene) and overlaps the Oligocene formations; it is overlain in places, particularly along the Gulf coast, by Pleistocene materials.[3] The thickness ranges from a feather edge on the northern boundary to 400 feet or more in places at or near the Gulf.

Matson summarizes the essential facts concerning the Citronelle thus: "Citronelle formation. Non-marine chiefly, including high-level terraces. Yellow and red sands and clays, locally gray where unweathered. Much gravel near the landward margin and in the valleys of the principal streams. Thickness, 50-400 feet."

He adds that the Citronelle sediments are chiefly fluviatile, but in part estuarine and in part shallow water near the strand line where there was some wave action; that probably extensive deposits were formed by spreading of materials by shore currents, and that no marine organisms have been found.

The dip of the formation, as given by Matson, is southward at degrees varying from 5 feet to 30 feet to the mile, steeper near the Gulf. In southwestern Mississippi it is around 6 to 8 feet per mile, steepening southwards to perhaps 23 feet. He states that the surface expression of the original Citronelle took the form of a succession of four plains, named in descending north-south order, the Brookhaven plain, the Sardis plain, the Canton plain, and the Loxley plain, each with its accompanying stream terraces; that is, each plain consisted of two portions which merged with each other at their points of contact—stream terraces and interstream plains. The elevations ranged from 500 and more feet to around 150 feet.

Doering[8] states that "there is in south Mississippi a surface formation which reaches a maximum thickness of 150 feet, and of which the lower 60 feet is gravelly sand, the upper 90 feet sand or clayey sand." It correlates, he says, "with the 150-foot sand and sand and gravel section on which the town of Citronelle is perched, and must be distinguished from the leaf bearing clay beds which are described as the type exposure of the Citronelle. Those clays are probably part of the Pascagoula formation." He states further, "The thousands of water wells in the upland area of south Mississippi find water in the basal 6 or 8 feet of the gravelly sand." This formation Doering calls the Willis formation. He expresses the opinion that there is no "Willis Citronelle" in Adams County, and would assign the "patches of gravel and sand found there under the loess, as Pleistocene deposits, terrace deposits, in a valley cut by the early Mississippi in the Willis-Citronelle uplifted plain." Doering's sketch map shows contours on the base of the Citronelle at an elevation of 400 feet or more a little east of Adams County, and he points out that in Adams County "only a few points along ridge tops reach 450, only a few ridges reach 400."

Matson,[8] noting that the sediments which he includes in the Citronelle are sometimes referred to the Pleistocene "because of their physiographic resemblance to the terraced deposits of Pleistocene age," states that they differ from the Gulf Coast Pleistocene by being more sandy and containing more gravel, by their mature dissection, and "by the weathered condition of the pebbles, many of which are composed of chert so completely decomposed as to break or even crumble easily in the hand." Another statement differentiates his Citronelle from other formations with which it is in contact: "The Citronelle formation differs from both the older and the younger formations in being predominantly sandy, with many lenses and scattered pebbles of chert gravel." He adds "The sand is predominantly quartz, and the pebbles in the Mississippi embayment are mostly chert, with a somewhat smaller percentage of crystalline quartz and quartzite."[8]

W. D. Chawner,[9] of the Louisiana Geological Survey, states: "After a perusal of the literature on the Citronelle and for the reasons given above, there seems to be much better reason for assigning the Citronelle to the Pleistocene than to the Pliocene."

For the purposes of this report, Matson's conception of the Citronelle and Chamberlin's definition of the Natchez will be accepted.

The outstanding features of the sand and gravel formations of Adams County will appear from the description of typical sections included in the discussion of the Natchez formation.

The best examples are in the bluffs along the eastern shore of Mississippi River, although excellent exposures show in the main watershed divides, and in some stream banks and road cuts. Underlying the Natchez sands and gravels are beds of coarser materials which are in this paper assigned to Matson's Citronelle.

In the river bluff sections, the contact between the sand and gravel body and the underlying Hattiesburg formation is at the base of a layer of either coarse conglomerate or ferruginous sandstone, both very conspicuous in the river bridge section (Fig. 4). Here the conglomerate is composed of chert and quartz gravel, chert and quartzite cobbles and bowlders, ironstone concretions, ironstone nodules, pieces of silicified wood, marcasite concretions, fragments of ferruginous sandstone and iron carbonate, and other substances. It lies as a crust on the Hattiesburg formation. A conspicuous feature is the great number of ironstone or limonitic concretions, most of which are hollow. Septarian nodules are not uncommon. The materials are almost entirely of a kind common in the so-called Citronelle and Natchez; in many places in the county quartzite cobbles and bowlders and large fragments of silicified wood are among the gravel well above the base of the formation, and concretions of several sorts are present in the sand. Perhaps the most abundant type of concretion is that which consists of a thin shell of ferruginous or non-ferruginous sandstone or of ironstone containing loose sand or clay or iron carbonate.

Shaw[10] expresses the view that the "hollow and fragile pebbles of iron oxide which contain a little clay" were formed by the replacement of the lime carbonate of limestone pebbles by iron compounds.

That the conglomerate is in part Recent and is being added to from day to day is testified to by glass bottles, recent mussel shells, pieces of manufactured iron, blocks of gneiss and basalt now used for rip-rap along the river banks, and other foreign objects cemented into the layer on the river bed. But that the layer is not merely Mississippi-River-laid is indicated by its presence at the base of the sand and gravel body several miles east of the river, in the headwater branches of Solitary Valley Creek, at the head of Clear Creek, at the head of Kittering Creek, and elsewhere. It is not present everywhere that the base of the formation is exposed. If the conglomerate is missing, however, sandstone or claystone is present at or near its level, both commonly ferruginous. In fact, the sandstone is present everywhere the conglomerate is, so far as observed. Masses of coarse gritty ferruginous sandstone are included in the conglomerate, and beds of cross-laminated coarse sandstone or grit rest on the conglomerate, except where gravel beds lie next above it. These relations are excellently shown in the river exposures.

In the county east of Mississippi River exposures of Citronelle materials are many in valley walls and in road cuts. In fact, sand and gravel are present almost everywhere beneath the loess, especially in the dividing ridges. With few exceptions, wherever the base of the loess shows in the upper slopes, it is seen to rest on gravel or sand or a mixture of the two with silt and clay.

A few of the largest or most significant of the outcrops in several parts of the county east of the river may be described briefly, in north-south order as far as practicable.

The northern part of the county is almost entirely a loess region, and has few, if any, good exposures of the underlying sand and gravel. In the deep and intricately dissected loess belt which borders the Mississippi River plain, the loess-sand contact can be followed for short distances up the bayous from their mouths; but east of Pine Ridge Road and north of Selma Road the stream channels are in general too shallow to reach the sub-loess formation.

The northeastern corner of the county, especially northeast of Coles Creek, is Citronelle terrane. The northeast wall of Coles Creek channel about 200 yards below the mouth of Mill Creek (Sec. 24, T.7 N., R.1 W.) is a 75-foot steep-sided ridge of cross-laminated ferruginous sandstone containing a noticeable percentage of grit and small gravel, chiefly along the structure planes. The rock ranges from strongly indurated to friable, or to loose sand. Large masses have fallen into the creek, and fragments are strung far down the channel. The same solid ferruginous cross-bedded and gritty sandstone forms the south wall of Mill Creek channel (Sec. 24, T.7 N., R.1 W.), 0.5 mile southwest of the Coles Creek outcrop and 0.3 mile above the Leesdale-Cannonsburg road crossing of Mill Creek. The end of the ridge, from creek floor level almost to the top, is hard brown rock from which a train of fragments reaches down stream.

Although ferruginous sandstone is not uncommon in the Citronelle, particularly at or near the bottom of the formation, no other place was seen in the county which shows such extensive development of this type of rock.

At the head of an eastward-descending small tributary of Coles Creek (Sec. 45, T.7 N., R.1 W.) on the east side of the Leesdale-Cannonsburg road, some 0.6 mile north of the junction of this road with U. S. Highway 84, and approximately 2 miles west of the Adams-Franklin county line, a gravel pit 131 yards long, 54 yards wide, and 40 feet deep on its west side, exposes probably the thickest gravel deposit of Adams County (Fig. 15). The walls of the pit are gravel almost entirely, the admixture of brown sand is relatively small, and of the clay is confined to scattered lumps of pink clay. The gravel is almost all chert, and of medium size in general, the largest cobble being 4 inches long.

The dividing ridge between the Coles Creek watershed on the east and the St. Catherine Creek basin on the west is in large part Citronelle, and a little below the heads of all the tributaries of both streams the sand and gravel crop out, as well as at a number of points along the stream courses below the head waters. Everywhere the formation is much the same, the differences being in the relative proportions of the rock types.

Citronelle gravel and sand are the rim materials of Clear Creek basin, and provide most of the alluvium of the creek channel. The best outcrops are provided by cuts for U. S. Highway 84 at the top

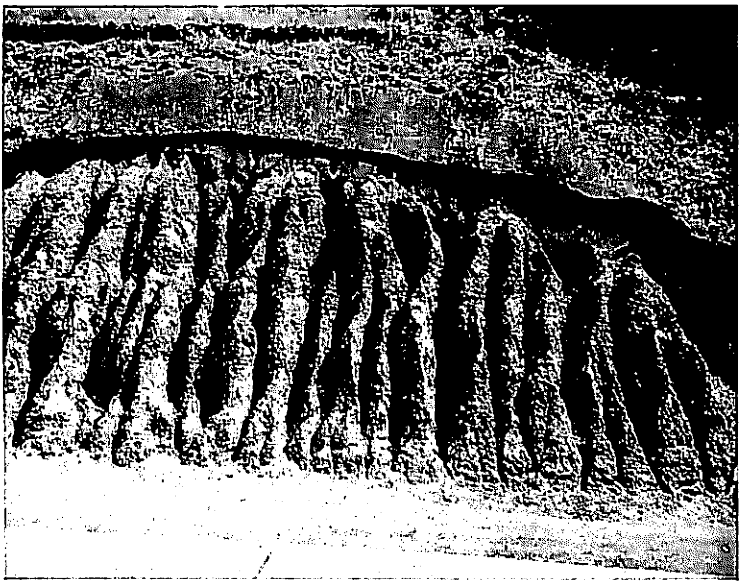

Figure 9.—Citronelle gravel and sand below, loess above; cut for U. S. Highway 84, top of west wall of Clear Creek Valley, Sec. 44, T.7 N., R.2 W. July 16, 1941.

of the east and west walls of the creek valley. At the top of the west wall (Sec. 44, T.7 N., R.2 W.) the Loess-Citronelle contact (Fig. 9) is well shown, sharp, and conforming roughly to the cross-section profile of the ridge. Some 20 to 25 feet of chert gravel and brown sand show in the walls of this cut. The elevation of the top of the gravel is close to 380 feet. In the walls of the cut at the top of the east wall of Clear Creek valley 0.5 mile farther east, the outcrop is very similar to that of the west wall; the loess-gravel contact is sharp and parallels roughly the surface profile of the cross-section of the ridge, with less relief, although only about 10 feet of gravel are exposed. The summits of the Clear Creek valley ridges and of a few other points along Highway 84 or old Highway 22, for short distances toward the east-southeast and the north, are the highest of the county, reaching elevations somewhere between 440 and 460 feet above mean sea-level. Possibly the superior height of this small area is due in part to the resistance of large accumulations of gravel.

Upper St. Catherine Creek appears to be more heavily loaded with gravel and sand than any other stream of the county, and the ratio of gravel to sand higher than elsewhere, probably because of great accumulations of gravel in its watershed, and steeper stream gradients. The St. Catherine Gravel Company has taken advantage of these conditions to locate its plant on the east bank of St. Catherine Creek a little below U. S. Highway 61 bridge over the stream 0.3 mile northeast of Washington. Enormous quantities of gravel and sand are obtained from the alluvium.

The head reaches of Kittering Creek and of its tributaries likewise reveal sections of sand and gravel. Half a mile or so below the head of the main headwater branch an outcrop of the sand contains lumps of laminated purple clay. The stream debris is almost entirely sand and gravel, and no surface water is present for at least 0.5 mile below the head of the valley.

A little below the head of Windy Hill Manor Creek, a branch of Kittering Creek which heads in Sec. 7, T.6 N., R.2 W. and flows northwest and north, the brown sand and chert gravel underlying the loess form a 15-foot vertical wall. The basal member of the outcrop is a ferruginous cross-bedded sandstone. Lumps of purple clay are worked into the associated sand. The channel of this tributary is choked with sand and gravel, and no water appears for about 0.5 mile down stream; from there on for some distance the flow is intermittent .

At the head of Solitary Valley Creek (Sec. 8, T.6 N., R.2 W.) a little west of the junction of Highland Church and Liberty roads, exposures made by the headwater branches show the greater part of the Citronelle. From these outcrops and the logs of five holes near by, the section described below is constructed:

SECTION OF HEADWATER BRANCHES AND DIVIDING RIDGE AT HEAD OF SOLITARY VALLEY CREEK (SEC. 8, T.6 N., R.2 W.)

	Feet	Feet
Holocene system		
Recent formation		
Soil, brown silt loam to level of Highland Church road		
Pleistocene system		
Loess formation		30.0

Silt, light to dark brown fine, oxidized sandy and clayey towards base	30.0	
Pleistocene and Pliocene systems		
Citronelle and Natchez formations		81.0
Sand, coarse to fine; yellow, brown, red-brown, etc. from iron stain; contains large to small gravel at various levels, and lenses and masses of pink and purple fat clay	80.0	
Conglomerate, ferruginous sandstone, black and purple sand, silicified wood, purple and red clay to the level of the creek bed at the junction of two branches	1.0	

The tributaries of lower St. Catherine Creek provide a number of good outcrops of the sand and gravel formations of the Citronelle.

SECTION OF RIGHT WALL OF LOWER WOODVILLE ROAD BAYOU ABOUT TWO MILES ABOVE SECOND IRON BRIDGE OVER BAYOU (SEC. 15, T.6 N., R.3 W.)

	Feet	Feet
Holocene system		
Recent formation		1.3
Soil, silt loam to the top of the channel wall	1.3	
Pleistocene system		
Loess formation		18.0
Silt, light-brown to gray, containing white snail shells; brown zone towards base; thin gravel bed at base	18.0	
Pliocene system		
Citronelle formation		22.0
Conglomerate, consisting of nodular sand and clay; brown sand containing white and pink sand and clay lumps; cross-bedded and otherwise irregularly bedded; upper part obscured by wash	6.0	
Contact irregular		
Sand, bands of brown and light gray, laminated and cross-laminated	2.5	
Contact even		
Sand, bedded, dark brown to black, somewhat consolidated	0.5	
Sand, golden brown, laminated; a few small white clay concretions; some cross laminated to the level of the bed of the bayou	13.0	

Second Creek appears to have failed to reach the bottom of the body of sand and gravel and subordinate clay, at any point along its course. Surface explorations as well as borings along its head-water branches, in its middle course, and in its lower course, found only gravel, sand of various shades of brown, yellow, gray, and white, and a small proportion of clay. Pockets and small masses of pure extremely plastic and tenacious purple, pink, and red clay, scattered through the sand, are conspicuous especially in the float, although they are only a relatively small part of the formations as a whole.

Of the numerous sand and gravel, chiefly sand, cliffs along Second Creek, the most conspicuous is the left wall of the creek channel east of Highway 61 about 8 miles south of Natchez. This is one of the finest exposures of this body of sand, gravel, and clay to be found in the county. About 0.4 mile east of the highway, the creek in

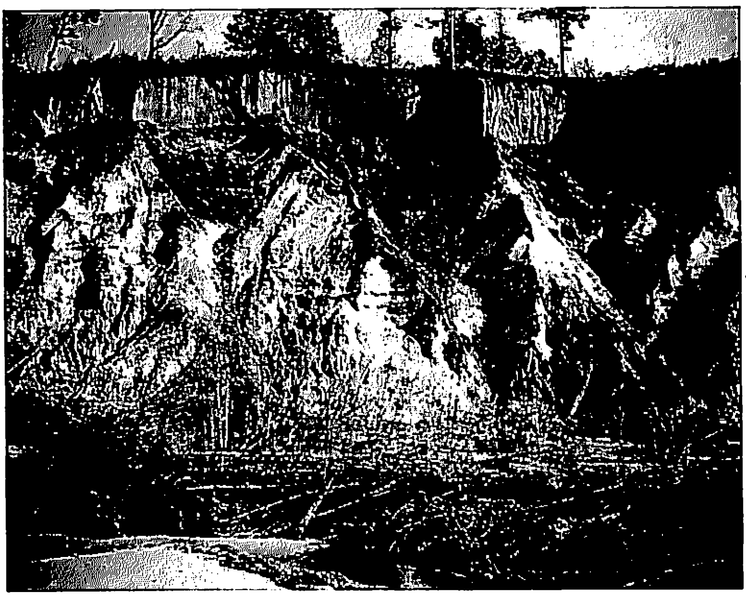

Figure 10.—Citronelle sand overlain by loess; cliff on Second Creek, Sec. 44, T.6 N., R.3 W. January 21, 1942.

making a swing to the left has cut through a hill of sand and loess, forming a curving face 150 yards long showing a thickness of 65 to 75 feet of sand and gravel and clay, and 20 to 25 feet of overlying loess (Fig. 10). The sand is whitish-gray to pink, very fine, and contains relatively little gravel, but masses and lentils of pink and purple clay and sand lend variety to the colors. In general these are more abundant near the base of the exposure. The base of the formation is not visible.

Also, the walls of the valley of Second Creek, particularly the left wall, at road crossings, show sand and gravel and loess only.

The new cut for upper Liberty Road (Sec. 27, T.6 N., R.2 W.) has made a conspicuous exposure of red-brown sand and some gravel, and the southeast wall of Second Creek valley shows abundant materials of the same kind along the old Kingston road.

In general the entire southern part of Adams County is buried in sand and subordinate gravel, so far as can be determined from the surface. Other materials show in very few places. East of Sandy Creek, in the Homochitto National Forest, the drainage is cut in sand and gravel chiefly, because the loess is much reduced in thickness. This part of the county is high in relation to the flats of Sandy Creek and Homochitto River, and is a maze of hills and valleys, heavily forested. All exposures observed show sand and gravel only, beneath the loess. The best of these outcrops are in the east wall of the valley of Sandy Creek, especially at road crossings: (1) Along the Cranfield-National Forest road, above and east of Sandy Creek bridge 2 miles southeast of Cranfield; (2) in both walls of the cut for the Jeannette-Knoxville road on the Carter plantation; (3) on the Carter property 0.5 mile north of (2) and about the same distance N. 75° E. of Carter's store; (4) in the cut for the road up a 180-foot bluff about a mile north of Carter's store; (5) along National Forest roads in the southeastern corner of the county, especially the road 1 mile south of road intersections and about the same distance west of Veals Creek (Secs. 20 and 31, T.5 N., R.1 W.); (6) in the west wall of the valley of Pretty Creek, along the road; (7) in the west wall of the valley of Sandy Creek on the B. Montgomery property, a few rods east of the Jeannette-Kingston road, in the southwest corner of T.6 N., R.1 W.

In the southeastern corner of the county (Sec. 72, T.5 N., R.1 W.), a light-gray very fine-grained sandstone shows in a place or two along the Homochitto River road a mile west of Veals Creek and a mile south of road intersections. This sandstone has a maximum thickness of about 2 feet, and is continuous for perhaps 0.3 mile. On the east side of the main forest road, in and near an old road which leads along the power line right of way, the sandstone forms a capping for the hill, and a ledge along the upper part of the hill slope. It is underlain by fine sand of many colors to considerable depths, as shown by borings in the vicinity.

In the cuts of the east-west road which leads across the county from the southeastern corner to Hutchins Landing, a little clay shows here and there with the sand and gravel. On old Highway 61, also, at Town Creek, 0.5 mile northwest of Kingston, clay shows at the base of the loess. The clay beds may belong to the Pascagoula formation, but probably are lenses and small bodies interspersed with the sand and gravel, such as show in many parts of the county and are conspicuous in Highway 84 cuts east of Adams County.

THE NATCHEZ FORMATION

The name, "Natchez formation," seems to have originated with Chamberlin,[11] who states:

"At Natchez, Mississippi, there is a section of assorted material about 200 feet in thickness, which is chiefly made up of derivatives from the Lafayette formation, upon which it rests unconformably, but also contains crystalline pebbles and calcareous clays assignable to wash from the glacial regions, all other assignments seeming to be excluded by a special examination. A marked interval between its deposition and that of the overlying loess is indicated. As the sub-Aftonian and Aftonian deposits are the only older ones with which great gravel deposits are known to be associated, and as the Natchez deposit must be referred to an early Pleistocene stage because the great Mississippi trench, sixty miles more or less, in breadth, has been excavated since it was formed, reference to one of these two stages is more plausible than to a later one. This reference is strengthened by the fact that almost the whole formation—which was clearly a valley train leading back to the drift area—has been removed. . . . ."

Matson[3] states that his oldest and highest Pleistocene terrace, the St. Elmo, which is sub-Aftonian in age, merges into the Natchez formation. He identifies his 150-foot Pleistocene terrace with the Natchez formation.

Logan[12] includes the Natchez in three sections he describes, all in the vicinity of Natchez. His "Section at Gravel Point North of Natchez," which he states is "one mile north of the Yazoo and Mississippi Valley Railroad station," probably is the same as the section 0.4 mile north of Learned's lumber yard and west of the City Cemetery, described in the present paper. He assigns the Natchez a thickness of 100 to 150 feet, describing it as "sands with gravel, tumultuously cross-bedded," and allows only 8 to 10 feet for the underlying Citronelle, which he calls Lafayette.

Lowe[7] describes the Natchez formation, "In the river bluffs at Natchez overlying the older gravel deposits of the Citronelle, is a mass of reworked gravels and sands which seem to be of early Pleistocene age. The materials of the formation are derived in part from the older Pliocene deposits and in part from the glacial drift coming from the north. This deposit differs from the older Pliocene gravels in that it contains in considerable proportion rounded pebbles of igneous rock derived from the glacial drift. Brown oxide concretions of various, and often bizarre forms, are common.

"The Natchez formation underlies unconformably the loess of this region. The distribution of this formation is not well known, being most conspicuous at Natchez, where it has been studied. It was

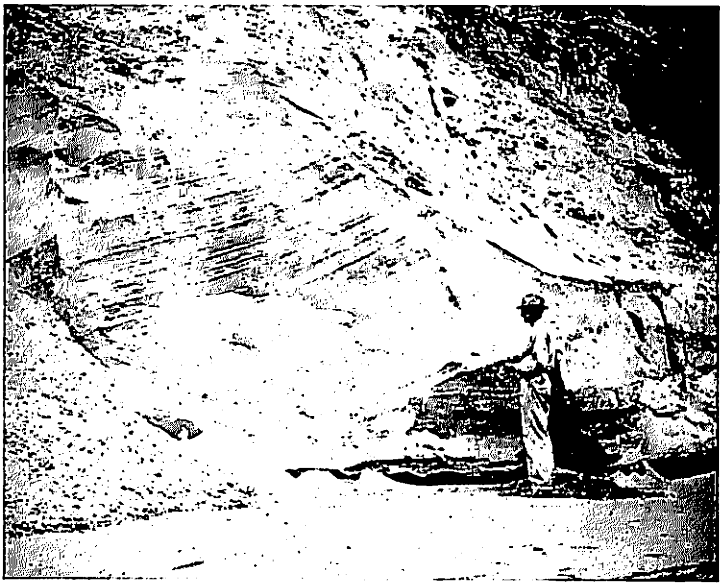

Figure 11.—Natchez sand, U. S. Loess Deposit bayou, Sec. 12, T.8 N., R.3 W. September 4, 1940.

a river deposit at a time when the Mississippi was surcharged with waters and debris from the melting glaciers to the north. In the bluffs at Natchez it has a thickness of 75 to 80 feet."

Stephenson, Logan, and Waring[4] refer to an unpublished manuscript by Shaw in which the Natchez formation is described as a very early Pleistocene stream deposit consisting of 150 to 175 feet of gravels, sands, and clays. Shaw[10] stated in an earlier paper: "At Natchez a thin layer of terrace gravel is overlain unconformably by a heavy deposit of river sand, which is apparently of early Pleistocene age, for it contains very deeply weathered pebbles from Canada.

The formation which it represents has been so severely eroded that though a somewhat careful search has been made no other remnants of it have been found."

The character of the Natchez formation as observed by the present survey is indicated by the descriptions of several sections along the river bluff.

SECTION OF NORTH WALL OF BAYOU WHICH OPENS INTO MISSISSIPPI RIVER AT U. S. LOESS DEPOSIT 0.3 MILE BELOW CROSSING OF MISSISSIPPI POWER AND LIGHT COMPANY POWER LINE.

	Feet	Feet
Recent or Holocene system		
Recent formation		3.0
Soil, dark silty and slightly sandy; notable humus, to top of bluff	3.0	
Pleistocene system		
Loess formation, 35 feet thicker 100 yards north		92.0
Loess, light-gray to light brown (buff) to light yellow on surface; brown where fresh; numerous white lime snail shells; fine velvety silt where pure; basal zone of several feet is iron brown from oxidation	92.0	
Natchez formation		62.6
Concretionary material, black; sand, and some gravel; probably maganiferous (Old soil ?)	0.5	
Sand, fine, light-gray to brown, containing numerous black grains, and some small gravel; laminated and cross-laminated	5.0	
Gravel, chert, medium-sized and small, and grit and coarse sand; bedded; forms a conspicuous vertical-faced ferruginous band near the top of the formation	2.4	
Sand, medium-grained, gray to light yellowish laminated and cross-laminated; small gravel scattered thinly through	6.8	
Gravel and sand: gravel coarse (maximum 4 inches long) to fine; horizontally bedded; gravel almost entirely chert	1.3	
Sand, gray fine to coarse cross-laminated; top 0.4 foot brown; small gravel along laminae planes; partly covered by talus from above	11.5	
Sand, grit, and small gravel, vertical face: Sand dark-brown to red-brown, highly ferruginous, coarse; interval laminated horizontally and diagonally; gravel strung along lamination planes	4.3	
Sand, dark-brown to red-brown, talus slope; gray coarse sand beneath, dark-brown sand mixed with gravel above	3.3	
Sand, fine gray to greenish-gray, laminated and cross-laminated; upper part a vertical face	4.5	
Sand and gravel talus slope: gray sand and ferruginous red-brown sand mixed with chert gravel	8.0	

Sand, ferruginous yellow laminated cross-laminated; black grains; fine-grained to medium-grained; vertical face (Fig. 11)	15.0	
Pliocene system		
Citronelle formation		37.0
Conglomerate, composed of large to small chert gravel, and cross-laminated ferruginous sandstone	2.0	
Gravel, conglomerate, sand, and grit; gravel ranges in size from a maximum cobble 4 x 5 x 3 inches to smallest pebbles; almost all chert, some small quartz pebbles; all gravel mixed with sand. Sand coarse-grained to medium-grained, orange-yellow to light-yellow to reddish-brown to almost black; cross-laminated; some beds free from gravel and slightly consolidated, forming somewhat resistant beds. No beds are uniform; lentils interwedge. Vigorous streams of clear, cold water issue from the gravel at different levels	20.0	
Covered for most part; shows, in addition to sand, gravel, and conglomerate, some white sand lentils, and scattered masses of white, plastic, yellow-streaked clay which may be top of Hattiesburg ?	15.0	
Miocene system		
Hattiesburg formation		3.0
Clay, blue sandy to river level at the mouth of the bayou	3.0	

SECTION OF EAST BLUFF OF MISSISSIPPI RIVER 0.4 MILE NORTH OF THE LEARNED LUMBER YARD AND WEST OF CITY CEMETERY, NORTH NATCHEZ

	Feet	Feet
Holocene system		
Recent formation		1.0
Soil, silty and sandy to the top of the vertical face of loess	1.0	
Pleistocene system		
Loess formation		14.0
Silt, fine light brown, containing white lime snail shells; iron-red zone at base	14.0	
Natchez formation		80.0
Clay and sand, laminated blocks	5.0	
Sand and gravel: Sand laminated, cross-laminated, gray, yellow; gravel in lentils in sand, also scattered through sand	75.0	
Pliocene system		
Citronelle formation		38.0
Sand and gravel, as in interval above	20.0	
Gravel and sand: remnant of small river terrace, or alluvial apron of wash from bluff	6.0	
Mostly covered, but at top a yellowish clay, which may be re-worked	10.0	
Conglomerate: Large to small pebbles and cobbles and bowlders; hollow iron oxide concretions	2.0	

Miocene system		
Hattiesburg formation		30.0
Clay, brittle sandy bluish to greenish; yellowish on surface in places; drying cracks at surface; hackly fracture; resembles bentonite. Partly covered to the level of the Mississippi River	30.0	

SECTION OF EAST BLUFF OF MISSISSIPPI RIVER AT RAVINE A LITTLE SOUTH OF NATCHEZ-VIDALIA BRIDGE

Holocene system	Feet	Feet
Recent formation		1.0
Soil, light brown loam to the top of the bluff—elevation 225 feet	1.0	
Pleistocene system		
Loess formation		70.0
Silt, very fine light brown to yellowish; massive; contains many white lime weathered shells of land snails; slumps and slides on underlying clay	70.0	
Natchez formation		96.6
Clay, massive iron-red silty; gradational contact above	1.0	
Silt, clayey, and clay, silty; laminated, and laminae defined by limonitic stains; base defined by limy and iron oxide laminae	3.7	
Silt, laminated limy light brown, at base; more clayey higher up; hard limy masses and veins	9.0	
Clay shale, light-gray, laminated somewhat lignitic slightly sandy slickensided; limy hard seams or veins	3.5	
Irregular contact, hard limy layer	0.1	
Sand, light brown to dark brown; coarse, laminated. To bottom of pit	1.5	
Sand, brown laminated cross-laminated; coarse at top, with some grit. Bedding and lamination more conspicuous toward bottom; oxidation at base, and some clay balls enclosed in ferruginous sandstone shells; also blocks of underlying clay	20.0	
Clay, gray very sandy laminated closely jointed; breaks in cubical or oblong blocks which fall and hold together for some distance down the ravine; colored pink, red, and other colors by iron oxide, especially towards the bottom. Contacts with overlying and underlying sand are sharp	2.8	
Sand, gray strongly laminated, laminae defined by iron oxide and more conspicuous in upper 3 feet, which are faintly cross-bedded; lower 2 feet light-gray, very fine, cross-laminated; to bottom of ledge at foot of waterfall	5.0	
Covered; sand wash, etc., but bluff face at same levels not far above and below shows fine gray to brown cross-laminated sand with some gravel, so intervals: presumably Natchez	40.0	

Sand, fine gray, some 200 yards southwest of bridge pier; lies on wall of coarse to fine gravel 10.0

Pliocene system

Citronelle formation 35.0

Gravel, coarse to fine, chiefly chert, vertical wall, overlain by fine gray sand, 200 yards southwest of bridge pier .. 10.0

Covered, gravel and sand, largely talus or wash; abundant clear water flowing from base 20.0

Sandstone and grit, ferruginous cross-laminated; conglomerate at base 5.0

Miocene system

Hattiesburg formation 9.0

Clay, hard dark bluish to greenish; to water level of Mississippi River, about 20 feet above mean Gulf level 9.0

Further data relating to the formation at the bridge were obtained from the material from six wash-boring holes by the bridge construction company, F. K. McDermott, at the site of Contract No. 3 embankments. Holes 1, 2, 3, 4, and 6 are tabulated according to intervals:

	Description of material — Hole / Elev.	1 115.1	2 113.9	3 113.2	4 109.6	6 111.0
1	Loess	0-8	0-8	0-8	0-3	0-8
2	Clay, fine sandy				3-12	
3	Sand, fine, and clay, yellow, with sand becoming coarser	8-45	8-39	8-54	12-36	8-33
4	Sand and gravel	45-51	39-63	54-63	36-51	33-51
5	Sandstone		63-70			

Holes 1, 2, and 3, close together in the same gully, passed through identical material; hole 4, through slightly different material, being fine sandy clay beneath the loess; but Hole 6, through material similar to that in holes 1, 2, and 3. That in hole 5, 60 feet right of the center line, differed from all the others.

RECORDS OF HOLE 5, ELEVATION 107.9

Interval	Description of material	Depth
1	Loess	0 - 10
2	Clay, fine sandy; sand becoming coarser	10 - 26
3	Clay, red, containing a few small sharp rocks	26 - 37
4	Gravel, apparently in sand	37 - 64
5	Gravel, with sand	64 - 75

Mr. McDermott noted that the thickness of the loess was uniform and that both loess and sand sloped with the floors of the gullies, but that the surface of the gravel was undulating and did not slope with the floors of the gullies; also that it was higher at the boring closest to the river.

The elevations indicate that the holes were started a little below the top of the Natchez formation, and the depths show that Holes 2 and 5 reached the Citronelle.

SECTION OF EAST BLUFF OF MISSISSIPPI RIVER ON HUTCHINS LANDING ROAD, SEC. 16, T.5 N., R.3 W.

	Feet	Feet
Holocene system		
Recent formation		1.0
Soil and subsoil to the top of bluff north of road; elevation 281.0 feet	1.0	
Pleistocene system		
Loess formation		55.0
Silt, gray to light brown	55.0	
Natchez formation ? and Citronelle ?		115.0
Sand, light-gray to white fine cross-laminated; contains grit in places, also small pebbles and some larger gravel; variously colored by iron oxide	112.5	
Conglomerate, sandy ferruginous, and sandstone, cross-laminated ferruginous. Partly covered, and doubtfully in place, but abrupt change of slope here	2.5	
Covered; sand and blocks of ferruginous sandstone to road junction on river flat, 60 feet above mean Gulf level		45.0

Briefly, as appears from the descriptions, the Natchez is made up of sand, gravel and grit, silt, and clay, but the gravel and grit compose only a small part of the formation. The sand is commonly very fine, and ranges in color from whitish gray through darker gray, light-yellow, darker yellow, brown, red brown, to black; a very large percentage of it is gray, with abundant black grains. The gravel is chiefly chert, and ranges in size from cobbles several inches in longest dimension to very small pebbles. A small percentage of quartz, quartzite, and igneous and metamorphic rock pebbles is present. Logan's description, "Sands with gravel, tumultuously cross-bedded," is apt. Diagonal and curved lamination is the rule, rather than the exception, and in many places the gravel is strung along the lamination planes, in other places it is scattered thinly through the sand. Accumulations of gravel are conspicuous in some sections, but commonly small. Mechanical analyses of clay and sand respectively from near the top surface of the Natchez formation by the U. S. Department of Agriculture Bureau of Soils are quoted by Shaw:[10]

	Percent
Fine gravel (2 to 1 millimeters)	.0
Coarse sand (1 to 0.5 millimeter)	.0
Medium sand (0.5 to 0.25 millimeter)	.1
Fine sand (0.25 to 0.1 millimeter)	3.2
Very fine sand (0.1 to 0.05 millimeter)	12.8
Silt (0.05 to 0.005 millimeter)	46.8
Clay (0.005 to 0 millimeter)	37.2
Total	100.1

Fine gravel, 0.0; Coarse sand, 0.3; Medium sand, 1.0; Fine sand, 19.1; Very fine sand, 26.7; silt, 39.4; Clay, 13.5; Total, 100.0.

The Citronelle-Natchez contact is one of disconformity, but is difficult to determine, partly because of the slumping or wash, and partly because Citronelle gravel has been reworked into the overlying unit and Natchez sand carried down into the Citronelle gravel. In the U. S. Loess Deposit section the contact could be found with a fair degree of accuracy, because of the conglomerate and ferruginous sandstone at the top of the Citronelle. In general, above a certain level in any one place the gravel is disseminated more widely through the sand than it is below that level, and is aggregated in the form of stringers along bedding or lamination planes, or of lentils or small lenses. Also, the ratio of gravel to sand is much lower, and the sand is finer and less ferruginous; the greater part of the gravel is small, and the percentage of quartz pebbles higher. A feature, too, besides the presence of pebbles of igneous rock, is the high polish of many of the small pebbles, a polish so brilliant that the surface of the pebble may reflect objects.

As mentioned, Lowe[7] states that the distribution of the Natchez formation is not well known beyond the type locality. The present survey found abundant evidence that the kinds of materials included in the Natchez in the river bluff extend some distance to the east, but their separation as a geologic unit from the Citronelle or from the waste sand of the Pascagoula is next to impossible almost everywhere. Many of the stream courses are choked with fine gray to white sand which might well have been part of the Natchez formation, and gravel and sand accumulations almost everywhere, when searched, yield some igneous or highly polished pebbles. Yet, among all the outcrops of sand and gravel east of the river bluffs, in only one place did a unit appear which might be considered with some assurance as Natchez in place. This place is the west wall of a southern branch of upper Solitary Valley Creek (Sec. 10 or 14, T.6 N., R.2 W.). Here, on the outside of a sharp bend, the golden brown and the gray sand just under the loess are exposed to a height of 25 feet above the floor of the branch. As in the river bluff, the gray sand is featured by its fineness, its intricate cross-lamination, and by the numbers of very highly polished small pebbles. Also, some igneous pebbles are present, and a notable percentage of black pebbles. The high polish of the surface may possibly be due to wind action or to abrasion by "Glacier flour" or other very fine abrasive material during water transportation.

The Natchez formation contains bodies of sandy clay of various forms, some of which are exposed in the river bluff sections. An outstanding example is at the top of the bridge section, where the uppermost 16.3-foot part of the Natchez forms a conspicuous lens of clay shale and silt, excellently exposed by excavations for the bridge approach. Its bedding and lamination are very prominent, especially in contrast with the massive loess above.

The eastern limits of the Natchez formation could not be determined, but the unit is thought to be relatively narrow. Probably the great body of the formation originally occupied part of the area now included in the Mississippi River trench, and what is still in Adams County is only a small remnant of the original formation.

The general characteristics of the Citronelle and Natchez may be summarized as follows:

The formations are composed of sand, gravel, conglomerate, ferruginous sandstone, and clay, of which sand is most abundant, gravel second in abundance, and clay a rather minor component.

The sand ranges from coarse to fine, but a very large proportion of it is fine.

The gravel ranges from cobbles or even bowlders to grit, and is composed in large part of chert, but includes a considerable proportion of quartz, especially among the smaller gravel, and some crystalline pebbles. All the gravel is rounded in varying degrees. It is distributed in discontinuous layers, lenses, lentils, or stringers at various levels through the formations, but commonly the thickest deposits and the largest gravel are at or near the base, where bodies of gravel mixed with relatively little sand are not uncommon.

Cross-bedding and lamination are present almost everywhere in the sand, the patterns of lamination being complicated in many places. Also, the sand of the Citronelle is in general oxidized in varying degrees, and as a result has a wide range of colors of the yellows and browns. In contrast, the sand of the Natchez formation is fine and gray and has a notable proportion of black or dark grains.

A conglomerate is present at the base of the body in many places, and irregularly laminated ferruginous sandstone at many other places.

THE LOESS

The loess is the uppermost rock formation of Adams County, except for the soil and the stream wash; in fact, most of the soil and a considerable part of the stream wash have originated from the weathering of the loess. The loess is spread more or less over the entire county, except where removed by erosion.

Loess, from whatever locality, is a very fine velvety silt, where it has not been affected by the weather. The color ranges through bluish-gray, buff, and various shades of yellow and brown to almost red or nearly black, but the commonest color in Adams County is light-brown to pale yellow. Color is due to the iron or organic matter where weathering agencies have affected the material, the percentage and distribution of these and the degree of oxidation of the iron determining the color of the body of the loess.

The loess maintains a remarkable uniformity of texture and other characters over wide areas. Fresh loess from any one place in the county is about the same so far as physical characters are concerned as that from any other place. "This material. . . . . was found to be most remarkably uniform, both horizontally and vertically. Samples taken 10 feet apart, 10 miles apart, or even 100 miles apart, had substantially the same mineral composition and the same range of particle size."[13] Perhaps the outstanding physical characteristics of the loess are: (1) The extreme fineness of the particles; (2) the irregularity of shape of the particles; (3) the massive structure and the vertical cleavage of the body of the loess; (4) its great power to absorb water; (5) its lack of coherence; and (6) its capacity to stand in vertical walls and resist weathering.

A record of the results of mechanical analyses of weathered loess by the Bureau of Soils, U. S. Department of Agriculture, is given by Shaw:[10]

Loess 20 feet below surface at south edge of Natchez, Miss.

(1) Fine gravel (2 to 1 millimeters)	.1
(2) Coarse sand (1 to 0.5 millimeter)	.1
(3) Medium sand (0.5 to 0.25 millimeter)	.0
(4) Fine sand (0.25 to 0.1 millimeter)	.2
(5) Very fine sand (0.1 to 0.05 millimeter)	5.6
(6) Silt (0.05 to 0.005 millimeter)	86.9
(7) Clay (0.005 to 0 millimeter)	6.3
Total	99.2

Measurements under the microscope show that 96 percent or more of the fresh loess is made up of particles less than .0025 millimeter in diameter, and only 1 percent of more than .005 millimeter in diameter.[14] As a rule, the particles of unweathered loess are fresh and sharply angular. Large bodies of loess, where eroded, present vertical-faced walls which retain their verticality through long periods of time, and even retain scratches and grooves for years. These features can be seen in road cuts all around Natchez, and throughout Adams County, especially in the western part (Fig. 3). Without doubt the great porosity of the material permits rapid absorption of water, and thus helps prevent washing; interlocking of the angular particles, also, may retard erosion. The absorptive capacity and perhaps the vertical cleavage, are said to be due in large part to multitudes of very small tubes or canals, perhaps formed by root fibers.[14] Yet, in spite of the characteristics of the loess which cause it to stand in vertical-faced walls and resist erosion, its coherence is so slight that the silt may be easily crumbled in the hand.

The chemical composition of the Adams County loess is indicated in the analysis below:[12]

Insoluble matter	67.377
Peroxide of iron	5.920
Alumina	.139
Potash	.104
Soda	11.934
Magnesia	2.804
Brown oxide of manganese	.171
Phosphoric acid	.138
Sulphuric acid	.002
Carbonic acid	8.976
Organic matter and water	3.087
Total	99.932

The mineral composition of the loess is chiefly quartz, feldspar, mica, iron minerals, dolomite, and calcite.[14]

The U. S. Engineer Office, New Orleans District, advises that its studies "tend to show that loess is identical in composition, regardless of its source."[15]

The problem of the origin and mode of accumulation of the loess has never been solved to the satisfaction of everybody. The loess of Mississippi is held by some authorities to owe its present position and some of its characteristics to wind action. These students of the loess believe that during certain stages of the great ice age, melting of the huge glaciers north of the Ohio River in the summer season released enormous volumes of water which poured southward to the Gulf, creating a river far larger than the Mississippi, that carried stupendous quantities of glacial "rock flour," or finely ground rock turned out by this glacial mill. They state further that during the intensely cold winters when the melting of the glaciers was retarded, the flow of the river was so much reduced that wide, almost dry silt flats, bare of plants, were left exposed to sun and wind, and that the prevailing southwest winds, sweeping across the flats, lifted clouds of dust, dry silt, which settled on the hills and in the valleys along the eastern wall of the river valley, accumulating to great thicknesses close to the river plain, and as a progressively thinner blanket towards the east. The small deposits of loess on the western side of the river are attributed to irregular winds which blew from the northeast, east, or southeast at times. The topographic position of the loess, the massive structure, the land fossils, the uniform texture, and other features, seem to point to the wind as the last agent concerned in the history of this material.[7]

Other students of the question hold that the loess was laid down by water, even in its present positions, and that the winds had little or nothing to do with the processes involved in its history. Still other geologists think that all three agents—ice, water, and wind—had a great part in the origin, transportation, and deposition of the loess. Each and every protagonist cites geologic "evidence" in support of his particular view, and the mass of data has not yet been thoroughly sifted, evaluated, and made the basis of an explanation which would answer all questions to the satisfaction of all students of geology.[14]

Certain other features of the Adams County loess are interesting and significant. The loess was deposited on the surface of a land mass dissected by streams and of moderate relief to relatively great relief. It is found on hill (Fig. 3) and in valley of this pre-loess land, fresh and apparently undisturbed at both extreme levels and also at any level between. From top to bottom it contains the white lime shells of land snails; also in some places it contains numbers of bones and teeth of the mastodon, an elephant-like animal which lived during the Pleistocene period (glacial times). Thus that in its present position it was not water-laid as a body seems strongly suggested not only by its generally massive structure and its homogeneity, but by its topographic position and its land fossils. Its presence at almost all levels, its relative uniformity of thickness at different levels, the absence of evidence of shifting of its materials, suggest eolian deposition. Moreover, Lowe[7] claims to have found "in the deep cuts of the National Park at Vicksburg an irregular stratification showing cusps and depressions simulating dune structure."

Good brief descriptions of the loess and critical discussions of hypotheses concerning its genesis and history are contained in two recently published bulletins of the Mississippi Geological Survey.[16], [17]

The three zones of the loess, discussed in recent Mississippi Geological Survey bulletins,[16], [17] show in many places, but are absent or inconspicuous elsewhere in Adams County. The unoxidized bluish-gray basal zone is exposed in several localities, and was penetrated in several test-holes; but the outcrops appear to be most prominent at the lowest levels reached by the loess; for example, the bottoms of the deepest bayous, where the loess is thick, as in Cemetery Bayou, Mammoth Bayou, Melvin Bayou, lower Kittering Creek, and lower St. Catherine Creek. Except in such places, at almost every exposure of the base of the loess, its contact with the underlying geologic unit, composed of sand and gravel almost everywhere, but clay at a few points, is at the top or somewhere in a thickness of oxidized material which varies from sandy and clayey silt through silty and clayey sand to relatively pure ferruginous sand or clay. This oxidized zone ranges in color from a light-brown or yellow through darker brown to deep red brown, and shows all gradations of oxidation colors between these extremes. The zone outcrop may be only a few inches wide, or it may have a width of 15 to 20 feet, or even more. Conspicuous exposures may be seen: (1) In the north wall of the cut for the Government Fleet, U. S. Engineer Depot, highway (Secs. 25 and 27, T.7 N., R.3 W.) on "The Briars" and "Magnolia Bluff" plantations, about a mile southwest of the city limits of Natchez; (2) in the excavations for the Natchez-Vidalia bridge, South Canal Street, in Natchez; (3) in the walls of a number of cuts for U. S. Highway 61 both north and south of Natchez, and for U. S. Highway 84 southeast and east from Washington; (4) in the walls of numerous cuts for Pine Ridge Road, Liberty Road, Kingston Road, and local roads; (5) in stream channel walls in many localities.

It is certain that the loess, accumulating (if it did) through eolian agency on an irregular land surface, would in the early stages of deposition mix with the soil there, which no doubt was a red or brown sandy loam or gravelly loam or clay loam, and impart some of its character to that soil, just as the brown loam farther east has mixed with older soils. Thus, although the contact of the loess with subjacent rock materials would be everywhere one of disconformity, that contact, none the less, would be gradational in many places. The field conditions indicate that such processes were operative and that such a relationship exists today. The fine silt appears to have worked down into the underlying gravel and sand through pressure from above combined with expansion and contraction due to temperature changes and wetting and drying, and also to have been carried downward by seeping water into the highly permeable materials below to such an extent that the formational contact has been obliterated, and gravel may be found in a matrix of ferruginous silty sand or sandy silt. Obviously, under such conditions, the actual contact lies above the uppermost gravel, in the absence of any evidence of stream action or slides. However, at few places does the oxidized contact zone maintain the same level for any considerable distance; it seems rather parallel to the present topography, but with lesser relief, in much the same way that the water-table conforms to the surface topography.

The loess contains great numbers of the pulmonate gastropod shells, land snails, so characteristic of the unweathered loess, as well as abundant lime concretions of almost every conceivable shape and a range of size from large masses to very small nodules. The genera and species of gastropods, identified by Associate Professor Ross E. Hutchins of the Department of Zoology and Entomology of Mississippi State College, are:

Anguispira alternata Say
Polygyra albolabris Say
Polygyra albolabris alleni Wetherby
Polygyra obstricta Say
Polygyra elevata Say
Polygyra sp.
Omphalina sp.
Haplotrema concava Say
Englandina rosea Ferussac.

Of the 390 specimens examined, 330 belonged to the genus *Polygyra,* and of the genus, 164 belonged to the species *elevata; Englandina rosea* Ferrussac was represented by 26 specimens; and *Anguispira alternata* Say by 16.

That the loess is mainly of rather late Pleistocene age appears proved by its position above Matson's Pliocene Citronelle and above the Aftonian or sub-Aftonian Natchez formation; also by its contained Pleistocene mammalian remains. According to Chamberlin,[11] most of the loess was formed during the Iowan ice invasion.

In Adams County the loess lies unconformably on all older units which crop out, but chiefly on the Citronelle and Natchez gravels and sands. The maximum thickness of loess found by the present survey was more than 90 feet, in the Mississippi River bluff at the U. S. Loess Deposit (Sec. 12, T.8 N., R.3 W.). In general it is thickest in the river bluff, and thins eastward more or less uniformly over the region as a whole. The numerous borings made by the survey found extremely variable thicknesses, of course, due to the accidents of location with relation to geography and topography.

RECENT FORMATION

The recent formation of Adams County consists of the mantle rock and the alluvium. The mantle rock is the blanket of waste rock material which has been derived from the weathering of former bed rock, and lies on the present bed rock; it includes soil, subsoil, and more or less fresh waste. The alluvium is the water-transported and water-deposited material, consisting chiefly of rock waste which was at one time mantle rock.

The mantle rock is present everywhere except in places where it has been removed by stream wash or slides and the bed rock exposed. Its composition varies from place to place, but in general is given character by the loess, the uppermost of the bed rock formations. Where the loess is thin, the mantle is more sandy and gravelly; and in relatively small areas above the Hattiesburg and Pascagoula outcrops it is clayey and sandy. The composition of the deeper part of the weathered loess and also of the Natchez has been referred to in the description of the Natchez and Loess formations. The U. S. Department of Agriculture Soil Survey of Adams County[2] mapped 18 different soil types, but one type, the Memphis Silt Loam, derived from the loess, is shown as covering more than half the county.

The soil types are classified as silt loam, clay, silty clay, loam, clay loam, sandy loam, fine sandy loam, and riverwash; all are mixtures of silt, sand, and clay.

The alluvium makes up the flood-plains of the streams. In general it is in the form of lenses or discontinuous beds of sand, silt, clay, and gravel, each of which may be relatively pure, but in most cases consists of a dominant rock material, mixed with a smaller proportion of one or more of the other rock materials. A cross-section of Mississippi River flood-plain, for example, shows bodies of gravel sand, silt, and clay interwedged and interfingered in a complicated manner. A blue mud is conspicuous in the section in some places. In general, however, the alluvium is more sandy nearer the river, in the front lands and silty and clayey in the "back lands." This general statement holds true for the flood-plains of all streams.

The Mississippi plain west of the bluffs in Adams County is many miles wide and underlain by alluvium probably at least 200 feet deep. Homochitto River also has a wide alluvial plain, and the valleys of St. Catherine Creek, Coles Creek, Sandy Creek, and Second Creek have had considerable flats developed along them. A hole in the Mississippi plain near St. Catherine Creek (Sec. 54, T.7 N., R.3 W.) penetrated 14.9 feet of brown silt, 13.9 feet of greenish silty sand, and 11.8 feet of blue clay. Sand is by far the most prominent material in the channels of a number of streams, especially in the southern part of the county.

STRUCTURE

The regional dip of the Tertiary strata of Adams County is almost south—perhaps a little west of south. The average degree of dip of the Hattiesburg is given in geological reports as 15 to 20 feet to the mile, of the Pascagoula about 30 feet to the mile near Mississippi River,[4] and of the Citronelle 6 to 8 feet to the mile.[5] The degree of dip as observed by the present survey is brought out by a comparison of relative elevations of key beds and key contacts at the following places:

1. Along the base of the Mississippi River bluff the thin conglomerate which overlies the Hattiesburg formation dips, in a southwest direction, 30 feet in 1.9 miles, or about 16 feet to the mile. This does not exactly parallel the direction of maximum dip.

2. The rough-surfaced Pascagoula silty sandstone, "Davion rock," of the Clear Creek basin appears to dip some 30 feet in 0.6

mile, or at the degree of 50 feet to the mile, a little west of south. This is somewhat higher than the normal Pascagoula dip, but other evidences are present of disturbance of the beds in the Clear Creek area. Possible error in correlation should be taken into account, also.

3. Elevations on a Pascagoula silty sandstone which crops out in two headwater branches of St. Catherine Creek some 0.6 mile distant from each other north-south, showed a dip of 38 feet, or at the degree of 63 feet to the mile, in a direction slightly west of south. In this case, too, there was not absolute certainty of correlation, and it may be pertinent to note that one of the fault traces observed in Whitens Creek strikes through this locality.

4. The Hattiesburg-Pascagoula contact in the western headwater tributary of Sandy Creek on the E. Ratcliff property (Sec. 68, T.7 N., R.1 W.) has an elevation of about 265 feet. The same contact at the lower Kittering Creek section, 9.5 miles west of the Ratcliff property, is 160 feet. Thus this contact descends 105 feet between the two points, or about 11 feet to the mile westward, almost along the regional strike.

The south regional dip of the beds can be determined best in the eastern part of the county, where a single bed may show for considerable distances along water-courses which trend almost down dip. In the western Ratcliff tributary and the main Sandy Creek the top of the upper dense blue "fullers earth" clay descends 17 feet in 0.5 mile, or at a rate of 34 feet to the mile, in a direction a little east of south. In the main Sandy Creek the upper surface of this body of clay descends from 9 feet above water-level some 92 yards below the mouth of the western Ratcliff branch, to creek level 1.5 miles farther down stream. In this section of its course, the stream bed has a fall of perhaps 25 feet; the top of the clay bed descends 34 feet due south.

These calculations can be checked by reference to correlative beds which show along the upper Sandy Creek tributary which enters from the northeast (Sec. 24, T.6 N., R.1 W.).

Matson[3] refers in several places to deformation of the Citronelle in the Adams County region, especially in connection with his discussion of the Citronelle plains. He mentions that in western Mississippi deformation has altered the original slope of the stream terrace of the Sardis plain in such a way that the altitude of the plain is 75 feet higher near Natchez than at Vicksburg or at Woodville.

A stream terrace of the Canton plain has an elevation of 300 feet east of Vicksburg, 380 feet east of Natchez, and 350 feet near the southern boundary of Mississippi, according to Matson.[3] Thus Natchez is near the top of a small structural high, if Matson's observations are in general correct.

The Loxley plain stream terrace likewise is stated to slope northeastward from southern Jefferson County to southern Warren County at about the same degree as the Canton plain terrace.

Shaw[10] also refers to deformation of the Natchez region: "Some features [of the plains] suggest that a principal axis of uplift runs from Natchez to the northeast corner of the State, and another from Mobile northeastward, and other features suggest an east-west axis through Vicksburg and another through Natchez." The same writer makes the further statement: "The triangular area of which Jackson, Vicksburg, and Natchez form the corners has certainly been elevated in and perhaps after Pliocene times, and the place of maximum upwarp seems to have shifted southwestward during the epoch, for the deposits and plains are not only warped upward, but the earliest ones are uplifted most and the center of uplift is different for different plains and deposits."

Lowe[7] states, in his brief description of the Natchez formation, "Since its deposition an east-west axis of elevation has arisen in the latitude of Natchez, so that these terrace deposits dip both to the north and to the south." It is interesting to note, in connection with this statement, that Matson[3] holds that the post-Pliocene terraces are not deformed. A table of elevations of the contact of the body of sand and gravel with the overlying loess, elevations obtained by measurements along the river bluffs and a study of the Natchez topographic map, provides some interesting data with reference to this question. The outcrops, and the elevation of the top of the sand in each, are listed in north-south order:

Outcrop	Elev.
1. Fairchilds Creek:	
a. Upper outcrop, a little above the river plain	110
b. Lower outcrop, a little above the river plain	107
2. Bayou one mile northeast of Anna	125
3. Bluff 0.3 to 0.4 mile southwest of Quitman	160
4. U. S. Loess Deposit bayou	130
5. South end of Giles Cut, about	185
6. Bluff 0.4 mile north of Learned's lumber mill and yard	173
7. Bluff at foot of Jefferson Street, Natchez	155
8. Bluff at Natchez-Vidalia bridge	161

	Elev.
9. Bluff 250 yards north of U. S. Engineer Depot, contact not visible	120
10. The Briars bayous, The Briars plantation	145
11. Government Fleet hill, along highway south of U. S. Engineer Depot	148
12. Bluff between 11 above and St. Catherine Creek at Majorca Point, 95.0, 83.0, and 55.0, to 40.0 at the point.	

In the study of these data it should of course be borne in mind that the surface of the river descends less than 10 feet, perhaps only slightly more than five feet, between outcrops 1 and 12. Determinations of elevations, then, from river level as a datum, such as were involved in the preceding table, would be essentially accurate. In fact, inasmuch as the river had fallen to near an all-time low at the time the sections were measured, September through December, 1939, its surface descent was even less than that shown by the Natchez and Kingston sheets. It should be taken into consideration also, that the bluff extends southwest from 1 to 11, and almost south from 11 to 12. It is pertinent to note here, too, that at Hutchins Landing road, some 10 miles south of Natchez, the top of the sand, contact with the loess, in the river bluff is 220 feet above mean Gulf level.

It will be seen from the elevations that the contact under consideration rises irregularly from the northern boundary of the county to a point a little north of the city limits of Natchez, and descends irregularly from there to St. Catherine Creek, where it seems to be below flood-plain level. Farther south, however, at the Hutchins Landing road section, about nine miles due south of St. Catherine Creek, the top of the sand is at as great an elevation as that reached by the entire bluff face at Natchez.

Elevation data east of the river along a rough north-south line may be of assistance:

Location	Elev.
1. Jefferson County, 2.5 to 3.0 miles north of Stanton, Adams County, on old Fayette road	300
2. Highway 61 at Adams-Jefferson county line north of Verucchi's store (boring)	244
3. Highway 61, borings southwest of Stanton, between Stanton and Selma	257
4. Rokeby Plantation, L. Kaiser property, borings	363
5. Highway 84 cut in the east wall of the valley of Clear Creek	380
6. Clear Creek, head of left fork, north of Miss. Central Railroad	360
7. Head of Kittering Creek	360
8. Head of Solitary Valley Creek	330
9. Head of valley on west side of U. S. Highway 61, some 4.0 miles south of Natchez	293

The second table of data seems to confirm the story told by the first. It will be noticed that the Rokeby elevation, 4, and the U. S. Highway 84 cut elevation, 5, the greatest of the series, are only a little south of east of 5 and 6 of the bluff series, which are the maxima of that series.

At first glance, then, Lowe's statement concerning the east-west axis of elevation in the latitude of Natchez seems to be supported by the elevation data in the tables. However, because of the character of the sand and gravel formation and the manner of deposition, inferences drawn from such data should be considered suggestive only, and not by any means conclusive. Chamberlin held the Natchez formation to be a valley train, and pointed out that it was formed by filling of a southward-trending old valley by glacial wash. Thus the body of glacial sand, gravel, and clay gradually increased in thickness southwards, and reached a maximum towards its lower end, where the valley was deepest. Possibly all irregularities can be attributed to post-Natchez erosion, much of it prior to the deposition of the loess. Such data as could be obtained on the elevation of the top of the sand east from the bluff were not conclusive, but the appearance of the Citronelle bodies of coarse gravel immediately beneath the loess several miles east of the river seems to imply that the Natchez did not extend far east of the position of the bluff, or that it was removed before the deposition of the loess.

An examination of the information at hand relating to the underlying Miocene strata might be of help in solving the problem, although here we are confronted with the extreme difficulty of determining the exact topographic position of the Citronelle-Hattiesburg or Citronelle-Pascagoula contact, or the Hattiesburg-Pascagoula contact, except in a few places. Such pertinent data as have been obtained may be summarized:

As has been pointed out, the highest showing of the top of the Hattiesburg along the river bluffs, 30 feet above low water level of the river, is at Location 6 of the table of data. This is one of the two points of greatest elevation of the top of the Natchez as measured in the bluffs. About 8 miles due east of this point, the top of the Hattiesburg was thought to have been reached in borings at an elevation of about 285 feet, Rokeby plantation; but a boring in the valley of Hightower Creek, some 2.5 miles northeast of the Rokeby hole, found a black clay which may be at the top of the Hattiesburg, at an elevation of approximately 251 feet. If the black clay at the two locations belongs to the same bed, the bed rises towards the southwest 34 feet in 2.5 miles. An outcrop in Whitens Creek valley 3.5 miles a little south of east of the Rokeby location has an elevation of 316 feet, and the Hattiesburg-Pascagoula contact at Sunnyside, near the head of Sandy Creek, is 265 feet. The Kittering Creek section which exposes the contact 9.5 miles due west of the Sandy Creek showing, is 160 feet. It will be noticed that with the exception of the Hightower Creek elevation, which is doubtful, all those given above are consistent with a normal southerly dip.

On the insecure basis provided by the data summarized above, the conclusion could be reached that an anticline having an approximately east-west axis crosses Adams County, the axis of uplift lying a little north of the latitude of Natchez. Certain other conditions in the area have a bearing on the subject.

1. The peculiar course of St. Catherine Creek may have been determined in part by structure.

2. Faulting, on a scale not measured, has left a surface expression in at least two localities:

a. At the mouth of Walker Springs Branch, a small tributary of Whitens Creek (Sec. 8, T.7 N., R.1 W.), the main creek crosses a fault trace which strikes N. 20° E. The trace is bordered by parallel low ridges or bands of dark bluish to slate-colored and light-yellow clay which seem to be upturned edges of strata involved in the faulting. Some 50 feet below the fault trace, hard masses of much broken and indurated mottled sandy clay, tumbled at different angles, are exposed in the creek bed, and a few yards south of them an 8-inch to 1-foot friable white sandstone shows at the base of the right bank. About 0.3 mile upstream from this fault trace, another which strikes about N. 45° E. is crossed by the creek. It, too, is bordered by parallel bands or low ridges of gray and yellowish clay.

In an effort to learn more about the stratigraphic relationships in this area, as well as to obtain samples for testing, the present survey bored no fewer than 40 holes on the George Armstrong property, in the valleys of Whitens Creek and Walker Springs Branch. The course of the branch makes a low angle with the two fault traces. Walker Springs, which were well known many years ago, and visited by many people who were interested in their reputed medicinal properties, may owe their origin to the faulting of water-bearing strata. Some interesting discoveries were made by the test holes. For examples: A boring a few feet distant from the lower fault trace, on the down-stream side in the floor of Whitens Creek, reached a depth of 57 feet without having encountered water, whereas a hole only a few feet southwest of it, on the upstream side of the fault trace, found water at a little below 8 feet. A third hole, 10 feet down stream from the deep boring, encountered hard sandstone at a depth of slightly more than 11 feet, under gray clay all the way down, but no water.

No hard rock similar to that which shows in Whitens Creek at the lower of the fault traces crops out closer than a mile farther upstream, at the two waterfalls, and no yellow and gray clay like that which parallels the trace shows elsewhere in this area except at the Citronelle-Pascagoula contact, which is 60 feet or more higher than the fault trace exposure.

b. The second area where a fault trace may be seen is well up towards the head of the right headwater tributary of Sandy Creek mentioned in the discussion of the Pascagoula formation (Sec. 65, T.7 N., R.1 W., about 0.5 mile southeast of Cranfield). This trace strikes northeast-southwest across two forks of the branch a little above their junction. In both forks the outcrops show highly tilted yellow strata forming low ridges parallel to the fault trace, and dark-blue to dark-gray or almost black beds near by tilted at various angles. Near this fault, too, there is a vigorous spring issuing from the gravel, but springs are quite common, indeed they are the rule, at this horizon. The beds near the mouth of a lower branch also, have a notable dip.

These northeast-southwest faults, considered in connection with the elevations of key horizons, are believed to have some significance. It may be pertinent to note here that in a "geologic" report made several years ago on the Leesdale region of Adams County and a large adjoining area in Franklin County, certain investigators stated that they had found a very pronounced elongated dome. It must be said, however, that some untrue statements in the report, and others at least unsupported by field evidence, tend to raise doubts concerning the trustworthiness of all other material the report contains. Nevertheless it is mentioned here as evidence that the belief that a structure exists here is not new. On the map which accompanied the report in question, the Adams County limits of the surface expression of the structure were shown as crossing Whitens Creek about at the locality of the fault trace, and crossing Sandy Creek south of the mouth of the western Ratcliff branch.

3. In a number of localities of the county slumping and sliding have taken place on such a large scale that their effects are likely to be mistaken for conditions produced by deep-seated faulting. This is especially the case along the river bluffs, where the scarp of loess and sand and gravel is retreating eastward slowly but surely, due largely to sapping by water, of which strong streams issue from the gravel all along the base of the bluffs from the north end of the

Figure 12.—Slide at J. M. Jones Lumber Company plant, near U. S. Engineer Depot on bank of Mississippi River. September 21, 1939.

county to the south end. Slumping is especially active at times of low water, as in the fall of 1939, when on September 20, according to newspaper accounts three slides in quick succession carried into the river a mass of earth 200 feet wide and 100 feet deep (Fig. 12). Almost the entire sawmill plant of the J. M. Jones Lumber Company was engulfed, costing one life and a property loss of $40,000 to $50,000. The mill was situated on an alluvial bench some 200 yards from the base of the bluff.

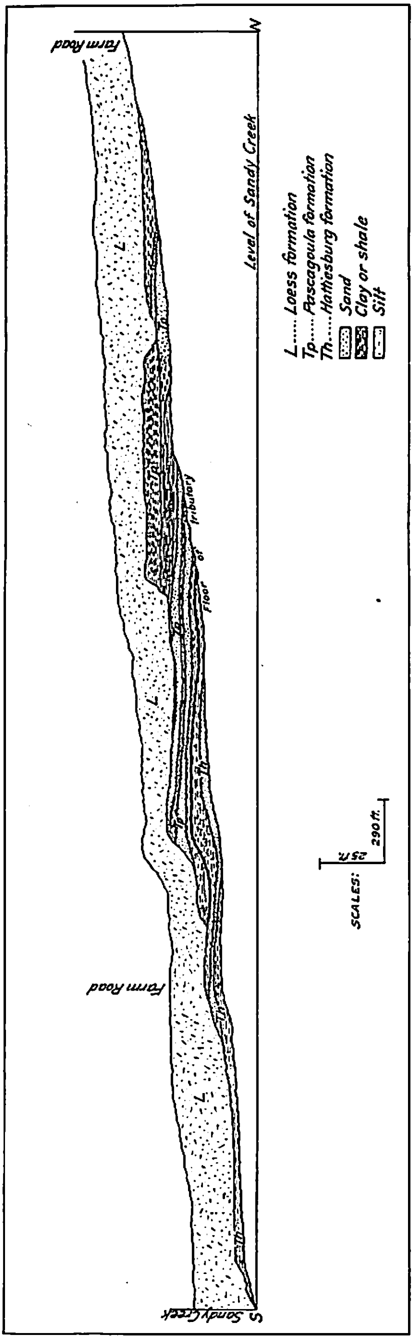

Figure 13.—Structure-Section along channel of tributary of upper Sandy Creek, Secs. 51 and 68, T.7 N., R.1 W.

A continuation of the slides along the river bluffs is inevitable. Great cracks have opened in the alluvium far back from the river, along almost the whole length of the bluffs, caused by the moving of the unconsolidated materials over the clays beneath. Sapping of the sand and gravel wall by the multitude of springs keeps conditions favorable for slumping at all times, but especially at times of low river, when the pressure of the river against the bluffs is released. Similar conditions prevail in many other parts of the county, and similar effects have been and will be felt.

Figure 14.—Inclined Pascagoula shales overlain by horizontally bedded Citronelle sand, Montgomery Creek, Sec. 66, T.6 N., R.1 W. Photo by W. C. Morse, March 14, 1942.

4. Dips steeper than normal have been mentioned. Other outstanding examples show in the walls of the channel of Montgomery Creek, a tributary of Sandy Creek which enters it in the southwest corner of T.6 N., R.1 W. The southwest wall of this valley about 0.5 mile above Sandy Creek is a vertical-faced cliff of dark-blue sandy clay and clay shale and sand overlain by iron-brown and whitish sands containing some gravel. The clay beds, Pascagoula, have a dip of 11° N. 73° W., although the brown cross-bedded sand overlying them, Citronelle or terrace, is essentially horizontal (Fig. 14). Some 250 yards farther up stream the northeast wall shows a similar strong dip in the same direction.

5. At least four deep wells have been bored in Adams County in search of oil or gas. The Brandon Hall well was located at a point now on the southeast side of U. S. Highway 61, about 0.5 mile southwest of Stanton, only a few yards from the right of way, and two miles or more north of the axis of the Natchez anticline, if such a structure exists. The A. C. Stowers No. 1 well (Sec. 29, T.8 N., R.2 W.) was on a minor high, as indicated in the table of elevations of the top of the Natchez sand: the well is about 3 miles due east of the Quitman outcrop, one of the highest of the bluff series. Recently Roy L. Fisher drilled S. H. Lambdin No. 1 (S.W. 1/4, S.W. 1/4, Sec. 36, T.8 N., R.2 W.), and L. H. Simpson the Fairchild Planting Company No. 1 (Sec. 18, T.9 N., R.2 W.). The elevation of the Simpson well is 89 feet D. F. above mean Gulf level; of the Stowers well, 253 feet; of the Fisher well, 260 feet D. F., and of the Brandon Hall well, 281 feet. The Simpson well reported the top of the Vicksburg at 950 feet, the top of the Jackson at 1130, and the top of the Wilcox at 3670; the Fisher well reached the Vicksburg at 1405 feet, the Jackson at 1545, and the Wilcox at 3940-50; and the Brandon Hall well reached the Vicksburg at 1550 feet and the Wilcox at 4077. The Simpson well is farthest northwest, the Fisher well some 4.5 miles southeast by south of it, and the Brandon Hall well 3 miles still farther southeast. It appears from the log data that the top of the Wilcox descends towards the southeast some 215 feet in 7.5 miles, or at the degree of about 29 feet per mile; and the top of the Vicksburg dips some 408 feet, or at a degree of 54 feet to the mile, in the same distance. However, possible errors in recognizing horizons must be allowed for, as well as possible changes in thickness of the beds and difference in elevation due to unconformities.

A structural map of a large area in Louisiana, chiefly from geophysical data by Louisiana oil men, came to the writer's notice. It shows the western part of Adams County well up on the slope of a "high," and a large fault crossing Fairchilds Creek a little above its mouth. Possibly the Stowers and Brandon Hall wells were bored on the strength of some such "evidence" of a favorable structure.

6. The extreme depth of the bayous in the western part of the county suggests slow uplift working along with erosion. It may be mentioned also that the so-called "Davion rock" exposed in the river valley bluffs at Fort Adams, Wilkinson County, at least 35 miles south of the Johnson Creek section of Pascagoula strata described in this report, seems to be lithologically identical with some of the intervals

(notably the "Davion rock" interval) of the Johnson Creek section. The stratigraphic succession at the two places is very similar, also. The rock at Fort Adams is of Pascagoula age, according to the geologic map of the state. Its elevation is 100 feet or less, and the elevation of the Johnson Creek "Davion rock" is 290 or more. That is, if the beds are identical, they descend less than 200 feet in 35 miles, or at the degree of about 6.5 feet to the mile; but the normal dip of the Pascagoula strata has been given by authorities as 30 feet to the mile in this region. Inasmuch as the thickness of the Pascagoula is given as 400 feet, the entire formation should dip beneath the level of Mississippi River flood-plain in 20 miles or so, if the elevation of the base of the formation at Johnson Creek is 250 feet; yet at Fort Adams, 35 miles south of Johnson Creek, the beds in question still reach some 75 feet above the flood-plain.

7. The relatively low elevation of the Citronelle in the Coles Creek basin may not be entirely explicable on the grounds of the unconformity at the base of the formation. Possibly down faulting was operative, with which the Whitens Creek fault traces may be connected.

GEOLOGIC HISTORY

Throughout pre-Pliocene geologic time the small area now within the limits of Adams County, Mississippi, was undergoing periodic marine submergence. Its recorded history for that time was a story of sedimentation for the most part, of building up of a sea bottom under a quiet or slow-moving shallow sea which shifted and distributed the waste gnawed from the land by the waves and the streams, and buried in it the teeming remains of once living things. But there were shorter periods when the warm waters drew back inch by inch from the little parcel of land and gave place to the sun and the wind and the rain and the flowing water which took constant tribute from the new land and gave to the old sea for the creation of a still newer land. During these periods the history of the region was a story of the birth, growth, and death of plants and animals which breathed the air of the atmosphere rather than that of the water—a story of land life rather than of marine life—and also a story of the slow destruction of the world on which that life existed by the elements and forces which created and sustained it. These degradational, destructive processes finally brought the spot again beneath the sea to end another cycle.

The rather monotonous rhythm of the changing relations of land and sea was varied now and then by more or less sudden adjustments of the earth's crust due to accumulated stresses, particularly down warping of the strata, but such disturbances did not change the course of regional history to any considerable extent.

In Adams County is recorded only a relatively brief period of the entire history. The Hattiesburg age was a time of marine conditions, when the chief geologic process in operation was deposition of fine sand and clay in a shallow quiet sea. The slow recession of the salt water brought the age to a close, but the land in many places was but little above the water surface, and soon, geologically, sedimentation was resumed over the whole area, inaugurating the Pascagoula age, which passed under conditions not unlike those of the Hattiesburg. The site of marine deposition was again shifted southward and the Adams County area was land once more, but its story continued to be one of aggradation, the building up of the low coastal plain by debris from the higher lands to the north. Through the Pliocene period these processes were dominant, and they held first place in physical history through the Pleistocene. In early Pleistocene time floods of glacier-born water swept southward down the Mississippi embayment to the Gulf, leaving huge bodies of rock waste to mark their courses, and re-working the earlier materials, especially the Pliocene, into a variety of topographic forms. The great Mississippi River trench testifies to the fierce activity of the Pleistocene and later waters. The next phase of the course of events brought to the fore a geologic agent which had hitherto played a rather subordinate role—the wind. It flowed down and across the great trench, sweeping up the fine grist of the glacial mill which the receding water had left in such vast quantities, and carrying it to the top of the trench walls to build them still higher, repairing the damage wrought by the ever active forces of demolition.

But geologic history is biological as well as physical. Post-Pascagoula ages in the little corner of the continent, as elsewhere, saw a drama of life enacted against the ever-changing background of land and sea. Plants and animals of strange aspect and almost infinite numbers came and went through all that time, and less than an hour ago, geologically speaking, the last of the lumbering mastodons came to the end of the trail and left his bones for the wind to cover over with silt and the water to uncover later for man, that strangest of all animals, to gaze and wonder at.

"Last scene of all, which ends this strange, eventful history," shows the little corner of land and the old, old agents of change at work on it, softening it and moving it to lower and lower levels, enroute to the sea. And the scene shows man the end product, the final development of the life processes, in frenzied activity, bending all other life to his will, controlling some of the natural forces and seeking control of all, changing the whole face of the earth through the exercise of such powers as no other type of living thing ever possessed, and yet "a house divided against itself," each of the parts striving to compel the others to recognize it as the dominant power of the universe. It may be that our Holocene period will witness the extinction of this highest of the animals; but if so, that will be only another incident in geologic history; the hills will continue to "flow from age to age" and the solid lands to "melt like mists," to shape themselves like clouds, and go. And the life forms over which man was given dominion will remain, and go on and on. Perhaps, after all, man is only a phenomenon known to paleontologists as a "sport" a freak which wastes its vitality in specialization, in the development of specialized and bizarre features for offense and defense. This tendency to "sport" is the last step on the road to extinction.

ECONOMIC GEOLOGY

SUMMARY OF FIELD WORK

The field work of the geological and mineral resources survey on which this report is based reached to every part of Adams County and included examination and sampling of every geologic unit and every type of mineral substance of the area. The results of the study of the geology are recorded under "Stratigraphy" and "Structure." In the course of the prospecting for mineral resources, 42 separate localities (Plate 1), widely scattered over the county, were prospected with the auger; some 600 holes, ranging in depth from 5 feet to 80 or more, were bored, and several trenches dug; 150 large samples and a considerable number of smaller samples of rock materials were transported to the laboratory at the University of Mississippi for testing and analyses. Most of the areas where borings were made are in the central east-west belt of the county, because most of the outcrops of the clays of economic interest and the largest tracts where those clays can be reached at relatively shallow depths are there. Samples of loess could be taken at almost any place in the county, and samples of sand or gravel at most places. A summary of field data covering the 17 localities from which the samples tested by the laboratory were taken, follows:

TEST HOLES	LOCATION AND PROPERTY	MAP
G 65, 67, 68, 70, 71, 118	Secs. 13, 14, 15, 18, T.7 N., R.1 W. G. Hightower	1
G 72, 73, 75-84	Secs. 8, 22, 23, 30, T.7 N., R.1 W. G. Armstrong	2
G 16, 17, 17a, 18-26, 55, 56, 58, 59, 66, 69, 120	Secs. 20, 35, 36, T.7 N., R.1 W.; Secs. 45, 46, T.7 N., R.2 W. Hicks Parker	3
G 9-15	Sec. 26, T.7 N., R.2 W. L. Kaiser	4
G 2-8, 8a	Secs. 22, 23, 29, T.7 N., R.2 W. J. M. Jones	5
G 27, 28, 29	Secs. 46, 47, T.7 N., R.2 W. John Smith	6
G 30, 31	Sec. 47, T.7 N., R.2 W. Jacob Johnson	7
G 32-35, 60-64	Secs. 44, 47, 62, T.7 N., R.2 W. W. Ratcliff	8
G 85, 86, 87	Sec. 83, T.7 N., R.2 W. C. W. Hazlip	9
G 36-49, 57, 89-94	Secs. 10, 11, 58, T.6 N., R.2 W.; Secs. 85, 86, 89, T.7 N., R.2 W. De Marco and Long	10
G 50, 51, 52, 95	Sec. 58, T.6 N., R.2 W. Green and Marlow	11
G 53, 54, 88	Secs. 84 and 90, T.7 N., R.2 W. Windy Hill Manor	12
G 109, 110, 111	Sec. 46, T.7 N., R.1 W. E. Blanchard	13
G 97-108	Secs. 50, 51, 68, 69, 71, T.7 N., R.1 W. E. Ratcliff	14
G 119	Sec. 65, T.7 N., R.1 W. R. Ratcliff	15
G 112-115	Secs. 45, 46, T.6 N., R.1 W. H. Carter	16
G 96	Sec. 1, T.5 N., R.2 W. Bailey, Clifford and others	17

CLAY

As pointed out, the geologic formations which crop out in Adams County contain a large proportion of clay. The Hattiesburg formation commonly is referred to as "Hattiesburg clay" and the Pascagoula formation as "Pascagoula clay," although the two units include many sand strata, and all the clay beds contain some sand, the Pascagoula clays being more sandy than those of the Hattiesburg. Also, clay and shale beds and lenses, most of them sandy or silty, are included in the Citronelle and Natchez formations.

The clay bodies are in general buried deeply under loess, sand, and gravel in the higher lands, but crop out or are relatively near the surface in the deeper valleys. In the 17 localities of the prospecting summary, thick beds of clay were found under relatively thin overburden, but in several of these the area is the floor and lower slopes of a narrow valley, where the overburden becomes excessive within short distances except along the valley axis, and the water-table is high.

Some localities where prospecting showed clay to be abundant and conditions for development reasonably favorable, are discussed below:

1. a. The Everett Ratcliff property (14 of summary), known as "Sunnyside," in the eastern part of the county, includes land on both sides of U. S. Highway 84 and the Mississippi Central Railroad. The surface slopes both north and south from the highway, and is trenched by tributaries of Sandy Creek on the south and Coles Creek on the north. The auger prospecting was confined to the valleys of three small streams south of the highway, and most of it to the small valleys separated by the ridge on which the Ratcliff home stands. Here, beneath a total area of at least 15 acres, thick beds of clay are present under slight overburden, as proved by some 21 holes bored. The logs show that clay beds predominate to the depths reached by the holes, and that the overburden of unconsolidated loess, sand, and gravel averages only 10 to 15 feet. In Hole G 98 a succession of clay beds totaling 40 feet in thickness was penetrated, including a single bed 25 feet thick, and in other holes comparable thicknesses were found. In general the water-level is low.

b. On the same side of the highway 0.5 mile or more farther west, 5 holes in the valley of another Sandy Creek tributary on the Ratcliff property found clay almost all the way down. Hole G 105, in this area, reached a depth of 76 feet, all of which except 2 feet was clay. The valley is narrow and steep-walled towards its head, but wider lower down, between walls of lower slope.

2. Some areas of the E. Blanchard property (13 of summary), north and south of Leesdale, are underlain by the same types of clays at slight depth (Holes G 109, 110, 111). North of Highway 84 about 0.5 mile, and north of the eastern Sunnyside tributary of Sandy Creek, a small branch of Coles Creek has cut into thick clay beds under the loess and Citronelle. The slopes here are low, and the overburden relatively thin over several acres. The place is reached by a farm road from Highway 84.

Also in the vicinity of the large "fullers earth" clay outcrop in Sandy Creek (Fig. 6) at and near the junction of a tributary in an area of perhaps 15 to 20 acres the overburden does not exceed 20 to

25 feet. This place may be reached via farm roads from Highway 84, but is most readily accessible from the east, where a road in Western Franklin County, extending south from Leesdale, is only about 0.7 mile from the outcrop.

The E. Ratcliff and Blanchard properties, because of their enormous tonnages of clay lying within easy reach of the surface and near a main pavement highway and a railroad, and also because of the good drainage of much of the area and the relatively low water table, probably offer more favorable development conditions than any other place in the county. In fact, in much of the area drained by upper Sandy Creek and its tributaries and some tributaries of Coles Creek, comprising the eastern part of T.7 N., R.1 W., great thicknesses of clay lie under relatively thin overburden, although the problems of accessibility and water are more difficult at greater distances from U. S. Highway 84 and the Mississippi Central Railroad, which follow the divide.

3. The area prospected on the H. Carter property (16 of summary) is part of the left wall of the valley of Sandy Creek. The clay beds are of considerable thickness here (Holes G 112-115), and the conditions for working reasonably good—moderate slope, little water, overburden not excessive, gravel roads near.

4. The Leslie Kaiser property (4 of summary) is rather favorably situated for the development of the clay beds. In most of the borings (Holes G 9-G 15) clay was found at relatively shallow depths, and a total of 50 to 60 acres was prospected. The slopes are moderate, and the farm is readily accessible via a good gravel road from U. S. Highway 61 only about a mile distant. Water would be troublesome at times.

5. The Jacob Johnson and John Smith farms (6 and 7 of summary) which adjoin U. S. Highway 84 on the north about 2.5 miles southeast of Washington, include some 10 acres under which clay can be reached at relatively shallow depths. Test holes G 27-G 31 found thick beds of clay and little or no water.

6. The Wallace Ratcliff property (8 of summary) in the Clear Creek basin south of U. S. Highway 84, is favorably situated and underlain by thick clay deposits, but much of it is rather steep valley wall and the areas where the overburden is not excessive are narrow. It lies between Highway 84 and the Mississippi Central Railroad, but is difficult of access.

The others of the 17 localities (1, 2, 3, 5, 9, 10, 11, 12, 15, and 17) are in narrow valleys, where only small areas could be worked under slight overburden. In each case, of course, the valley widens farther down, but promising clay beds may be missing there, and other conditions for development unsatisfactory.

The clays from the localities discussed in the foregoing paragraphs are chiefly from the Pascagoula formation, but in other places samples were taken from the Hattiesburg and from the Citronelle and Natchez. The characteristics and possible utilization of these materials are discussed in the section on laboratory tests. It may be mentioned here, however, that red sandy clay from the contact zone at the base of the loess has been used with some success as a binder for gravel on roads; in fact, this type of material from the John Nelson property, 12 miles from Natchez on Liberty Road, was given the highest rating as a binder during work on the roads of Adams County in the fall of 1939. This red brown to red sandy and silty clay or clayey and silty sand is found almost everywhere immediately below the loess, and may be an old residuum from underlying formations. Of course it is not everywhere of a type suitable for road binder.

Logan[12] classifies the flood-plain clays as sandy clay near the present streams, and a more plastic, inter-stream clay. He states that "By a proper mixture of these two clays, brick and drain tile of good quality may be manufactured."

GRAVEL

Gravel is extremely abundant in Adams County, and most of it comes from the Citronelle formation. It is chiefly chert, but has some quartzite pebbles, and a notable admixture of quartz pebbles, of which milky quartz is most prominent. The chert pebbles range in size from the maximum to the minimum which may be called pebbles; above the maximum size are a relatively few chert cobbles, and below the minimum is the grit. The pebbles are sub-rounded or sub-angular; relatively few are well rounded. They may be cracked or veined or even badly weathered.

The gravel has been used extensively as road metal and as aggregate for concrete. Almost all the secondary roads are graveled; very few public roads of the county are entirely unmetaled, because almost everywhere gravel is readily accessible. In many places, widely scattered over the county, pits have been opened where gravel has been removed for use in road building, the largest of these (Fig. 15), on the east side of the Leesdale-Cannonsburg road (Sec. 45, T.7 N., R.1 W.) is at the head of a tributary of Coles Creek, by which it has excellent drainage. In fact, most of the gravel beds are well up towards the crests of the ridges, occupying a position which insures good drainage. The overburden is loess only, or loess and

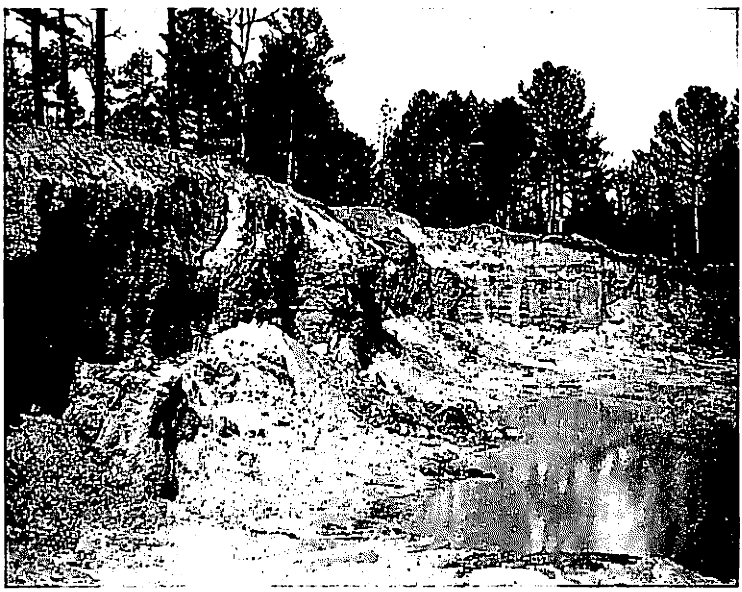

Figure 15.—Citronelle gravel, gravel pit, Sec. 45, T.7 N., R.1 W., on Leesdale-Cannonsburg road. February 18, 1941.

sand, and varies greatly in thickness, but is easily removed. In general the overburden is great in the western part of the county, but great quantities of gravel are available in the central and eastern parts, under slight covering and near metaled roads.

The St. Catherine Gravel Company, William J. Junkin, Secretary-Treasurer, established some 13 years ago, is the only sand and gravel company at present operating in the county. It has a large plant on the right bank of St. Catherine Creek at the creek bridge for U. S. Highway 61 northeast of Washington. The plant is well located for an abundant supply of gravel and sand, being only a few miles below the head of St. Catherine Creek, which rises in the highest part of the region in hills which contain probably the thickest deposits of gravel of any part of the county. Also, the plant is favorably located for transportation: U. S. Highway 61, a main pavement highway, is near at hand; U. S. Highway 84 is only about 0.5 mile distant, the Mississippi Central Railroad 1.5 miles south, and the Illinois Central Railroad, 1.5 miles north. The gravel and sand are dug from the channel of St. Catherine Creek by drag line, hauled by truck to the washing plant, and washed through screens which separate the sand from the gravel and assort the gravel into different sizes. The largest gravel is retained on a screen having a 2-inch mesh; the smallest (No. 4) on a 1/4-inch mesh; of the No. 4, 1 percent passes the 100 screen. The bowlders are scalped off. The largest gravel is used for highway purposes, and the smaller type for building purposes. The maximum output is about 300 yards of gravel and 200 yards of sand daily—that is, 500 cubic yards per day, each cubic yard weighing on the average 2,700 pounds. A fleet of trucks is employed: 10 to run the plant and 22 when the gravel is hauled direct to the job. During the recent great road building program and the construction of the Natchez-Vidalia bridge, the St. Catherine Gravel Company was doing a very large business, supplying almost all the gravel and sand for the bridge and for some 65 miles of pavement. In the ten piers of the bridge there is said to be enough sand and gravel to lay nearly 100 miles of pavement.

The supply of materials appears to be adequate. The plant has been operating almost continuously for 13 years. One 30-foot test-hole found gravel all the way down; another, at 12 feet below water encountered a yellow clay which could not be penetrated. In general the alluvial gravel and sand are resting on a blue clay base. The digging and loading of the gravel and sand have been and are carried on along several miles of the creek and its tributaries, but the accumulations are so great and the day by day wash from the hills so considerable that there seems little probability that the company will be forced to suspend operations because of exhaustion of the source of supply. If the St. Catherine Creek alluvium should some time prove inadequate, a number of other stream channels can be drawn on, because gravel is almost everywhere. Longer and more expensive hauls would be necessary, of course.

Lowe[20] quotes records of tests made of five samples of a mixture of chert gravel and sand from Adams County. The mechanical analyses showed that the gravel ranged in size from maxima of 4.4, 4.6, and 5.8 percent retained on a 1 1/2″ screen and 10.9, 14.3, 15.1, 18.5, and 26.6 percent retained on a 1" screen, to minima of 16.9, 16.8, 14.8, and 10.7 percent retained on a 1/4" screen. The sand ranged from a maximum of 65.7 percent retained on a 1/4" screen to a minimum of 8.2 percent passing a 200-mesh screen. The material was "examined for use as surfacing material in gravel road construction and as aggregate in reinforced concrete road construction."

SAND AND SANDSTONE

As stated, sand is very abundant in the formations of Adams County. The Natchez formation, except for scattered gravel and relatively small bodies of sandy clay, is composed of sand. The Citronelle also is made up largely of sand, and both Hattiesburg and Pascagoula formations include layers of sand, sandstone, and sandy clay. It is hardly to be wondered at, then, that outcrops of sand are numerous and the stream channels are choked with sand, which in many places has been built up by the water into bars and other deposition forms. Mississippi River shows excellent examples at times of low water, and the same is true of its larger tributaries.

Sand of all sizes, from the very finest up to very coarse sand and grit, is available in almost unlimited quantities, but in the western part of the county it is covered deeply by loess except in the deepest valleys. The main outcrops are in the face of the river bluff. The walls of the larger stream valleys show large outcrops, also, and of course the loess cover is thinner farther east.

A large proportion of the sand is fine. Almost all of it is colored with iron to various tints of brown or yellow or red-brown. However, here and there are showings of impure white sand—for examples, in the southern headwater tributary of Solitary Valley Creek and in the tributary of Sandy Creek which enters from the northwest (Sec. 3, T.6 N., R.1 W.). Very considerable bodies of the Natchez sand in the river bluff are gray, due to dull white quartz grains and a notable percentage of dark or black particles, probably ferromagnesian minerals.

The St. Catherine Gravel Company plant washes some 200 cubic yards of sand a day from the channel of St. Catherine Creek. Most of it is used in construction work; some in the building of pavement highways. The washed sand from the plant is the same as the sand of the bars in the streams; it appears white from a distance, but is dull white or gray. Much of the bedded sand of the county is more or less silty, and for most purposes would have to be screened and washed to remove silt, clay, mica, carbonaceous matter, and other impurities. The sand bar sand from the stream channels has been washed and sorted in varying degrees by the streams, but still contains sufficient silt and clay and other impurities to make further washing necessary before it could be used for industrial purposes.

Sand suitable for the manufacture of glass may be present in Adams County, but the greater part of the sand probably contains too much iron or mica, or both. In the Homochitto National Forest area, mentioned above, the auger penetrated more than 27 feet of white sand in one place, 25 feet in another, 26 feet in a third, and 49 feet in a fourth. Also, thicknesses of white sand as great as 12 feet and 22 feet were reported from holes bored a little west of U. S. Highway 61 in the southeastern part of the county, at the top of the north wall of Homochitto River valley (Sec. 2, T.4 N., R.3 W., and Secs. 26, 35, and 40, T.5 N., R.3 W.). Borings in other parts of the county penetrated several feet of sand logged as "white," but in some cases the "white" sand was light-brown.

In view of the abundance of sand in the county and the wide range of grain size, it is the opinion of the writer that sand suitable for any one of the commoner uses to which sand is put can be found. Of course it is probable that in most cases processing of some kind will be necessary. But "structural sand," for concretes, mortars, and plasters, has been obtained locally. In fact, "specifications for the different grades are to some extent written to fit supplies available in each locality."[21] Much of the sand is already free or relatively free from clay, silt, organic matter, iron sulphide, etc., and the considerable range of size of grain will permit uniform grading. As stated, however, while certain "white" sands might be worth investigating with a view to their suitability for the manufacture of glass, it is unlikely that any sizeable body of glass sand exists in Adams County.

Although sandstone crops out in several places, as mentioned in the discussion of the stratigraphy, it is in general too loosely cemented for use as a building stone. Here and there, however, the sandstone beds show a degree of induration and cementation approaching that necessary for building material, but the quantity economically available is not great, and in most cases the locations are not easily accessible. For example, in the southeastern corner of the county (Sec. 20, T.5 N., R.1 W.) a 2-foot bed of light-gray sandstone caps the hill on both sides of the Rosetta road through Homochitto National Forest, in the vicinity of the power line crossing. It is composed of fine light-gray sand firmly cemented into a hard rock, so far as the outcrops show. The top of the layer forms the surface of the ground in many places, and the edge forms low ledges along the top of the slopes, showing particularly well at the heads of the ravines. Probably the bed is due to local cementation. Some holes drilled only a short distance from outcrops failed to find any rock, but penetrated yellow and dull-white sand to depths of 40 feet or more. At least two of the holes struck the rock, one at 8.5 feet, another at 6.3 feet. This rock has been used in places along local roads to prevent washing; also used a little for foundations and chimneys.

LOESS

Loess has been and is being used for a number of purposes, the most important of which are discussed briefly herein:

In asphalt mixtures for the making of mattresses which are used for the protection of the banks of streams, notably Mississippi River, against washing. Loess intended for this purpose has been obtained in large quantities by the U. S. Engineers, New Orleans District, from the east bluffs of the Mississippi at the mouth of a bayou some five miles north of Natchez. The District Engineer refers to the place as Magnolia Bluff.[15] The laboratory mixture which complied most closely with the requirements of high sheer strength and tensile strength, relative hardness at high temperatures and relative flexibility at low temperatures, was known as "76 mixture," and had the following composition by weight:[13]

Asphalt, 30-40 penetration, steam-refined, petroleum, percent	12
Loess, all of which passed through a sieve having 200 meshes to the inch, percent	22
Sand-bar sand, percent	66

As a filler in the building of concrete highways. The Mississippi State Highway Department used loess as a filler in Highway 84, east and west of Brookhaven, Miss., in 1937 and 1938. It is to be used, or is now being used, on a highway job in Mississippi from Grenada to Houston, and it is understood that there is another job in the vicinity of McComb, Miss., where it will be used. It was included in the specifications of this district for the paving of the runways of Baton Rouge Airport, and a very large quantity will be used on that job.[15]

As a component of building block or brick material, along with asphalt emulsion and sand. In Adams County Dr. Chandler C.

Emery[18] conducted some experiments on his plantation, Poplar Grove, in the making of building blocks of various sizes from loess, sand, and asphalt emulsion. He states that in making a "batch" of the "bitudobe mortar" the components and their quantities were as follows:

Sifted clay (loess) mixed with water to make a thin mud, pounds	100
Asphalt emulsion, obtained from American Bitumuls Company, Baton Rouge, gallons	2
Sand, sifted, pounds	300

That is, the loess-sand ratio is 1:3 for each two gallons of asphalt emulsion. Dr. Emery has had at least two buildings constructed of this material near his home. He claims many advantages for such buildings, such as low cost, resistance to rodents and termites, freedom from dampness, coolness in hot weather, resistance to fire and frost, and so on.

As a component in the manufacture of brick. No brick plant is at present operating in Adams County, but Logan[12] states that formerly two plants, The Concord Brick Company organized in 1902, and the Natchez Brick Manufacturing Company established in 1897, were in operation, both using the fresh loess and the residual brown loam, or weathered loess. The Concord Company, using the soft-mud process, mixed three kinds of materials, a top loam, a middle plastic clay, and the subjacent non-plastic loess. The bricks were molded in a steam-power machine, dried on pallets in open-air racks, and burned in updraft kilns of the clamp type. The plastic clay was said to have a specific gravity of 1.97, an air shrinkage of 6 percent, and a requirement of 24 percent of water of plasticity; it slaked easily and rapidly. The briquettes lost about 5 percent in weight in passing from an air-dried to a burned condition. The clay pits of the Natchez Brick Manufacturing Company, a short distance from the Concord Company's pit, showed above the loess 3 feet of transitional material and 5 feet of clay. In the process of brick manufacture by the soft-mud method, the clay was prepared in a disintegrator and pug mill, and 1 foot of the loess mixed with 8 feet of the loam and clay. The bricks were molded in a steam-power machine, then placed on pallets, and dried in sheds, following which they were burned in clamp-kilns. The physical and chemical properties of the clay from the pits of the two companies were found to be very similar.

OIL AND GAS

Adams County has been and is being explored thoroughly for oil and gas structures by representatives of a number of companies, the surveys being made with instruments for the most part. Leasing has been lively, and at least two wells have been drilled during the last few months. Roy L. Fisher's S. H. Lambdin No. 1 (S.W. 1/4, S.W. 1/4, Sec. 36, T.8 N., R.2 W.) reached a depth of 7104 feet, and the L. H. Simpson Fairchild Planting Company No. 1 (Sec. 18, T.9 N., R.2 W.) was 6015 feet deep when abandoned. Neither reported more than slight showings of oil or gas, so far as has been ascertained. The A. C. Stowers No. 1 well (Sec. 29, T.8 N., R.2 W.) and the Brandon Hall well (Sec. 61, T.8 N., R.1 W.), drilled several years ago, reached depths of 2370 feet and 4510 feet, respectively; showings of oil were reported. Logs of the Brandon Hall and Stowers wells are a part of this report.

The structural features of the county, discussed in the section on "Structure," seem to be an east-west anticline of which the axis is about in the latitude of Natchez, and some faulting and abnormally steep dips, probably connected with the larger structure, in the central and eastern parts. On the basis of the very limited surface data which have been assembled by reconnaissance field work, the opinion is expressed that the east-central part of the county, somewhere near U. S. Highway 84 west of Leesdale, would have advantages over other parts of the county for the location of a test well.

A. C. Glassell et al. A. C. Stowers No. 1

75 feet west and 75 feet south of the northeast corner, Sec. 29, T.8 N., R.2 W. Begun June 27, 1930; completed September 17, 1930. Elevation 253 feet Gr., 257 feet Df

0-8	loam
243	red sand, clay
300	sand
500	blue clay
600	water sand
662	white gumbo
727	hard white sandstone
797	gumbo
824	sand rock
890	sand shale
922	sand
979	gumbo
1032	soft sand gravel
1041	sand
1048	green clay
1073	green gumbo
1081	green sandy shale
1138	gummy shale streaks sand
1160	sand boulders
1171	gumbo sand
1206	hard shale gumbo
1217	gumbo
1227	sand
1240	gumbo hard
1255	gummy shale with fossils drill stem test 1192-1255 showed salt water
1283	hard sandy lime with limy shale
1314	broken gumbo shale

1324	hard black gumbo
1500	hard gummy shale with tough gumbo streaks
1561	gummy shale
1766	hard gummy lime
1808	hard gummy shale
1809	boulders
1814	sandy shale
1816	gummy shale
1824	sandy shale with hard sand streaks
1836	brown sand, shale
1862	gummy hard lime
1885	hard shale
2040	hard sandy shale in thin streaks of gummy lime
2188	sand shale, boulders
2240	sandy brown shale streaks of lime sand streaks brown shale
2286	sand boulders
2309	shale
2319	sand shale sandy
2325	brown shale lime
2370	hard brown shale with lime boulders
	T. D.

ARKANSAS-LOUISIANA PIPE LINE COMPANY BRANDON HALL WELL

Lot 32, 201 feet from west line and 390 feet from south line, Sec. 61?, T.8 N., R.1 W.

Begun September 6, 1931; completed October 11, 1931. Elevation 280.56 feet P. T.

0-55	Surface sand and gravel
74	Pack sand
96	Water sand
165	Coarse sand, hard streaks
225	Pack sand
240	Sand and gravel
295	Shale, streaks of sand
335	Gummy shale
349	Hard sand
367	Gummy shale
460	Shale
508	Water sand
520	Shale
610	Sand and gravel
625	Sand, streaks of shale
695	Shale, streaks of sand
708	Shale
1009	Shale, gummy streaks
1031	Soft sand
1042	Hard pack sand
1054	Shale
1100	Sandy shale
1215	Shale, gummy streaks
1230	Sand
1256	Shale
1338	Shale, gummy streaks
1530	Shale, streaks of sand
1553	Sand; top of Vicksburg 1550
1558	Marl
1567	Broken limestone, gummy streaks
1577	Hard broken limestone
1609	Broken limestone; cores 1553-1586
1653	Gummy shale
1678	Sandy shale, fossil shells; greenish fossiliferous gummy shale; core 1656-1672; top of Jackson 1678
1780	Gummy shale
1794	Gummy shale; core 1780-1794
1930	Gummy shale
1972	Gummy shale
1978	Gummy shale
2038	Gummy shale
2095	Gummy shale
2109	Sandy shale and shells; gas?; core 2095-2109
2120	Sandy shale and shells; core 2109-2120
2123	Soft glauconitic sand; core 2120-2123; top of Cockfield 2123
2128	Sandy shale and lignite; drill stem test 2120-2128, 3 f.s.w. in 3 min.
2235	Shale, gummy streaks; streaks of sandy shale

2240	Shale, gummy streaks
2330	Shale, bowlders
2481	Shale
2488	Hard sand
2491	Hard sand
2566	Shaly sand, or sandy shale and hard streaks of sand
2585	Sandy shale and shale streaks
2603	Hard sand; top of Minden 2603
2619	Gummy shale, streaks of sandy shale; core 2603-2617
2652	Brown splintery shale and limestone bowlders
2722	Hard sandy shale
2730	Broken limestone and shale
2760	Hard sandy limestone; core 2752-2756
2778	Hard limestone, gummy streaks; rock bit 2756-2773
2802	Hard limestone, gummy streaks
2912	Shale, shells, streaks of limestone
2922	Rock; streaks of sand; hard limestone; top of Sparta 2920
2949	Soft shaly s. w. sand and sandy shale; core 2926-2940
2979	Sand and shale
2984	Hard pack sand
2999	Hard pack sand and sandy shale; sand carried s. w.; core 2984-2992
3078	Shale, sandy shale, and sand
3082	Hard sand and pyrite
3113	Hard sand, streaks of shale
3160	Hard sandy shale
3171	Hard sandy shale
3173	Sand rock
3242	Hard sandy shale
3268	Gummy shale
3271	Rock
3280	Sandy shale
3292	Gummy shale and sand; bowlders
3425	Sand and sandy shales
3475	Shale
3476	Rock
3488	Pack sand
3560	Sandy shale
3561	Rock
3620	Sandy shale
3692	Sandy shale, hard streaks; possibly Cane River below 3670
3712	Sandy shale, gummy streaks; top of Cane River 3712?
3746	Gumbo; reduced hole from 11 ½ to 9 ⅞ at 3716
3809	Gumbo, streaks of brown shale
3887	Gumbo, streaks of brown shale
3947	Shale, gummy streaks
3953	Hard glauconitic fossiliferous limy sand rock
3960	Green fossiliferous sand rock; core
3998	Green fossiliferous sand rock; core
4016	Green fossiliferous sandy shale; core
4022	Green fossiliferous sandy shale; core
4036	Green fossiliferous sandstone; core
4063	Green fossiliferous sandstone; core
4077	Green fossiliferous sandstone; core; top of Wilcox 4077
4091	Gummy shale, streaks of micaceous, carbonaceous sand; fossiliferous
4099	Hard sand
4101	Hard rock
4129	Sandy shale; fossil leaves common; core 4102-4108
4150	Sandy shale and bowlders
4250	Shale
4347	Shale, gummy streaks
4350	Shale, gummy streaks
4356	Green fossiliferous limy sand rock; core 4350-4356
4380	Shale and streaks of hard sand
4394	Gummy shale
4404	Gummy shale

4414 Hard sandy shale
4460 Soft micaceous carbonaceous s. w. sand; some lignite; core
4478 Sandy shale and shale with shells; s. w. 4478; core
4481 Green fossiliferous limy sand rock
4489 Hard brown shale and shells; core
4491 Soft sand, shale streaks
4510 Brown micaceous shale, shells; core

Total depth, 4510; dry, and abandoned in Cane River.

"FULLERS EARTH" AND BENTONITE

In descriptions of the Miocene beds references are made to the massive blue to greenish so-called "fullers earth" clay of the Hattiesburg. The appellation had its origin from the reports spread that this clay is a high-grade fullers earth, and the efforts to determine its value for purposes for which fullers earth is used. Numerous samples were taken and sent to laboratories for testing and analysis, with various results; but it appears that in general the tests were unsatisfactory, and that the material in question is not very efficient as a fullers earth.

Some beds of the upper Hattiesburg in places closely resemble bentonite, but they do not contain sufficient bentonite to be of importance, so far as was discovered by the present survey. However, their content of bentonitic or montmorillonitic materials may explain in part the peculiar properties of certain of the clays which make them very suitable for drilling-muds—properties discussed in the "Tests" part of this report.

WATER

Adams County has an abundant water supply provided by both underground and surface sources. Because the uppermost formations, loess, Natchez, and Citronelle, are very pervious, a large part of the copious rainfall is absorbed and much of it may reach the surface again through springs and wells. Springs are particularly numerous in the outcrop areas of the Citronelle and Natchez, and especially along and a little above the contact of the Citronelle with the more or less impervious underlying Miocene formations. As mentioned elsewhere in this paper, the flow of water from the Citronelle-Miocene contact and the gravel and sand above it during the low stage of the Mississippi River in the late summer and fall of 1939 formed an almost continuous spring along the base of the bluff north of Natchez. The people of the county obtain water from wells chiefly, most of which are less than 100 feet deep and draw from the Natchez and Citronelle formations; however, a few deep wells reach the water-bearing sand strata of the Pascagoula, the Hattiesburg, or even the Catahoula. In the flood-plain areas water is obtained from the sand and gravel beds of the alluvium through driven wells, and at places in the upland cisterns are used for the storage of rain water, either because the quantity of dissolved lime makes well water unsatisfactory for domestic use, or because, especially in the localities of thickest loess, the depth to water makes wells too expensive.

The wells in the city of Natchez draw from the Catahoula and the Hattiesburg sands chiefly, and range in depth from less than 200 feet to more than 600. The D'Evereaux plant of the Natchez water works has recently completed four wells starting from elevations of 220.23, 236.73, 231.34, and 213.23 feet above mean Gulf level, and reaching depths of 457, 612, 449, and 612 feet, respectively. Wells Nos. 1 and 3 apparently obtain water from the Hattiesburg and Nos. 2 and 4 from the Catahoula.

The record of mineral analyses of ground waters from Adams County[4] shows that the samples analyzed contained (at 180° C.) total dissolved solids ranging from 128 parts per million (spring) to 702 (Pliocene terrace sand), and a bicarbonate radicle (HCO_3) ranging from 98 (spring) to 739 (Pliocene terrace sand). Other substances listed as contained by the waters analyzed were SiO_2, Fe, Ca, Mg, Na, K, SO_4, Cl, NO_3. The total hardness as $CaCO_3$ (calculated) is given as 89 (spring) to 553 (Pliocene terrace sand).

SOIL

In Adams County, as in many, or most other counties of Mississippi, the soil is the most valuable mineral resource, because it controls in large measure the growth of plants and consequently the food supply for man and beast. The soil is, of course, the upper part of the mantle of rock waste produced by weathering of bed rock—the part in which plants grow or may grow. Beneath it lies the subsoil, which grades downward into the fresher mantle rock, which, in turn, is in more or less sharp contact with the underlying bed rock. Most soils contain humus, formed from plants through processes of decay and the activities of organisms, but the great bulk of the average soil is mineral matter. If humus is left out of consideration, the statement is true that the fertility of a soil is directly dependent on the quantity of mineral plant food which it contains in a soluble form; that is, in such a form that the plant can use it. And therein lies the great problem in the maintenance of soil fertility, especially in a region of heavy rainfall. Descending ground water takes into solution the readily soluble elements which growing plants must have, and carries them out of the soil, leaving finally only the insoluble or more difficultly soluble substances, such as alumina and silica and iron oxide. This depletion makes necessary the application of artificial fertilizers such as lime, potash, phosphate, nitrate, and others to supply the plant foods which never were present or have been removed by water.

The soil of Adams County is given character by the loess, which is the uppermost formation of the county almost everywhere. The loess is mainly a fine silt, and the soil derived from it is a silt loam, commonly known as the "brown loam." A record of chemical analysis of fresh loess is given in the description of the Loess formation, and further analyses records are included among "Tests." Briefly, fresh loess contains a considerable percentage of potash, soda, lime, magnesia, and phosphoric acid, all important plant foods. Mineralogically it is chiefly quartz, feldspar, mica, iron minerals, dolomite, and calcite. For the reason that the loess is rich in substances which plants use, the loessial soil is naturally fertile, and will retain its fertility under cultivation for a long time if proper farming methods are employed. However, most of the loess area has steep slopes and for this reason can not be cultivated very satisfactorily if at all; as is best, then, it is left in forest or pasture.

The soils which originate from formations older than the loess are in the eastern part of the county, for the most part. They are sandy and gravelly loams or clay loams, acid soils, which lack the fertility of the loessial soils. So widespread is the loess that almost every soil in the county can be said to have received contributions from it.

The soils of the Mississippi Alluvial Plain and the smaller alluvial plains are in a way composed of materials drawn from everywhere within the drainage basins of the streams concerned, and might be expected therefore, to have percentages of all the plant food elements present in the region. Within limits the alluvial soils in general are composites of all kinds of mineral matter which the running water has carried and do contain all the elements necessary for fertility; alluvial soils are known as the most productive of all. But in this connection the facts should be remembered that overflow waters sort rock detritus in the direction of flow, laterally, and vertically, and that the result of this sorting is the deposition of beds of relatively pure sand, and gravel, and clay, and silt, so that alluvial soils may be decidedly spotty. In general they are more sandy nearer the stream, the "frontlands," and more silty and clayey farther back, the "backlands." In most cases the fertility of an alluvial soil is due as much to the abundant humus present as to the mineral plant food.

TEST HOLE RECORDS

J. M. Jones Property

Test Hole G8-a

Location: T.7 N., R.2 W., Sec. 28 or 29; left bank of St. Catherine Creek where old road crosses creek, 0.9 mile below Highway 61 bridge

Drilled: July 30, 31, Aug 1, 2, 1940

Elevation: 199 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	7.4	7.4	Loess, brown silt, fine
			Hattiesburg formation
2	19.6	12.2	Sand, light-blue
3	22.9	3.3	Clay, light-blue; Sample 1
4	30.2	7.3	Clay, light-brown
5	34.2	4.0	Clay, light-brown
6	40.4	6.2	Sand, light-brown
7	45.4	5.0	Clay, light-blue
8	50.6	5.2	Clay, light-gray
9	53.7	3.1	Clay, light-gray
10	56.0	2.3	Clay, light-brown
11	59.0	3.0	Sand, dark-red
12	66.2	7.2	Sand, light-brown
13	80.4	14.2	Sand, light-brown

Leslie Kaiser Property

Test Hole G10

Location: T.7 N., R.2 W., Sec. 26, central part; on hill under pecan tree 1080 ft. north of St. Catherine Creek, 300 ft. east of fence

Drilled: Oct. 27, Nov. 2, 3, 1939

Elevation: 285 ft. Water level: 33 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	3.0	3.0	Loess, light-brown, fine silt
			Citronelle formation
2	15.0	12.0	Clay, gray, and gravel
			Pascagoula formation
3	28.0	13.0	Clay, gray, hard; Sample 1
4	34.0	6.0	Sand, gray; water
5	44.0	10.0	Clay, gray, very hard; water

Leslie Kaiser Property
Test Hole G11

Location: T.7 N., R.2 W., Sec. 26, central part; 375 ft. northeast of G10 under big oak tree, 185 ft. south of summit of high hill

Date drilled: Oct. 27, Nov. 2, 3, 4, 1939

Elevation: 301 ft. Water level: 48 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	20.0	20.0	Loess; silt, brown, fine
			Citronelle? formation
2	33.0	13.0	Clay, white; sample 1
			Pascagoula formation
3	35.5	2.5	Clay, light-green
4	48.0	12.5	Clay, white, sandy; water; Sample 2

Leslie Kaiser Property
Test Hole G12

Location: T.7 N., R.2 W., Sec. 26, central part; in old road near cemetery on top of hill, some 750 ft. south of Goodin Road, 225 ft. northwest of G13

Drilled: Nov. 2, 3, 4, 6, 7, 8, 9, 1939

Elevation: 348 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	19.8	19.8	Loess, brown silt
2	20.7	0.9	Sand, brown, silty
			Citronelle formation
3	35.0	14.3	Clay, grayish-brown, sandy
			Pascagoula formation
4	39.4	4.4	Clay, gray; Sample 1
5	43.5	4.1	Sand, gray
6	46.3	2.8	Clay, gray, tinted with yellow
7	50.0	3.7	Clay, gray, tinted with yellow; Sample 2
8	57.2	7.2	Clay, red, tinted with gray; Sample 3
9	62.0	4.8	Clay, gray, tinted with yellow
10	64.0	2.0	Clay, dark-gray
11	66.3	2.3	Sandstone, gray

LESLIE KAISER PROPERTY

TEST HOLE G13

Location: T.7 N., R.2 W., Sec. 26, central part; just below cemetery 225 ft. southeast of G12, 38 ft. below top of cemetery hill

Drilled: Nov. 3, 4, 6, 1939

Elevation: 327 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	4.8	4.8	Loess, brown silt
			Pascagoula formation
2	20.6	15.8	Clay, light-blue to light-gray or greenish-gray; Sample 1
3	26.8	6.2	Clay, light-gray to greenish-gray

LESLIE KAISER PROPERTY

TEST HOLE G13 OUTCROP TRENCH

Location: T.7 N., R.2 W., Sec. 26, east central part; on east slope of hill 90 ft. from summit, 225 ft. southeast of G12 Dug: Nov. 7, 8, 9, 1939

Elevation 327 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.0	5.0	Loess; fine brown silt
			Pascagoula formation
2	7.0	2.0	Clay, light-gray to greenish-gray; Sample OCTR

LESLIE KAISER PROPERTY
TEST HOLE G14

Location: T.7 N., R.2 W., Sec. 26, eastern part; on east end of pasture near an old road about 200 ft. south of Goodin Road; north of G13

Drilled: Nov. 3, 4, 6, 7, 1939

Elevation: 342 Ft. Water level: 40 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	20.0	20.0	Loess, light-brown silt
			Citronelle formation
2	26.0	6.0	Sand, gray
			Pascagoula formation
3	28.0	2.0	Clay, yellow sandy
4	36.0	8.0	Clay, blue streaked with red; hard; Sample 1
5	38.0	2.0	Clay, blue streaked with red; hard
6	44.0	6.0	Clay, gray sandy
7	45.0	1.0	Clay, yellow sandy
8	52.0	7.0	Clay, gray sandy
			Hattiesburg? formation
9	56.0	4.0	Clay, very black; Sample 2
10	60.0	4.0	Clay, gray

LESLIE KAISER PROPERTY
TEST HOLE G15

Location: T.7 N., R.2 W., Sec. 20, NW. corner; in hollow 450 ft. northwest of Kaiser-Parker property line gate on Goodin Road

Drilled: Nov. 7, 8, 9, 1939

Elevation: 333 ft. Water level: 34.3 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	14.5	14.5	Loess, silt, brown
			Pascagoula formation
2	15.5	1.0	Clay, gray, sandy
3	22.6	7.1	Clay, gray; Sample 1
4	23.9	1.3	Clay, brown with coarse sand
5	28.9	5.0	Clay, gray
6	33.0	4.1	Clay, yellowish-gray
7	34.3	1.3	Clay, yellow, pink and gray; water
8	43.0	8.7	Clay, gray, sandy

Hicks Parker Property

Test Hole G16

Location: T.7 N., R.1 W., Sec. 20, SE. part; on right bank of branch of St. Catherine Creek, 840 ft. from St. Catherine Creek, 110 ft. from branch at mouth of ravine — Drilled: March 21, 22, 23, 1940

Elevation: 289 ft. — Water level: 37 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.2	8.2	Silt, dark-brown (loess)
			Pascagoula formation
2	8.5	0.3	Sandstone, dull-white fine-grained
3	14.8	6.3	Clay, gray streaked with red; Sample 1
4	18.9	4.1	Clay, gray streaked with red
5	28.9	10.0	Clay, gray streaked with red
6	30.2	1.3	Clay, grayish-brown sandy
7	38.0	7.8	Clay, blue sandy; Sample 2
8	40.8	2.8	Clay, blue sandy

Hicks Parker Property

Test Hole G19

Location: T.7 N., R.1 W., Sec. 20 or 35, S.20 or SW.35; on east side of south tributary of St. Catherine Creek, some 0.6 mile above main creek, north of small bayou — Drilled: March 21, 22, 23, 1940

Elevation: 335 ft. — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	0.8	0.8	Loess
			Pascagoula formation
2	25.0	24.2	Clay, gray
3	25.2	0.2	Clay, gray
4	31.8	6.6	Clay, blue; Sample 1
5	32.5	0.7	Clay, blue

HICKS PARKER PROPERTY

TEST HOLE G20

Location: T.7 N., R.1 W., Sec. 35, western part; on south side of St. Catherine Creek about 300 ft. from creek, and 600 ft. southwest of the mouth of a tributary Drilled: March 19, 1940

Elevation: 304 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	9.0	9.0	Loess, brown, fine silt
			Citronelle formation
2	11.0	2.0	Clay and sand
			Pascagoula formation
3	22.0	11.0	Clay, gray and red; Sample 1
4	28.0	6.0	Clay, red, very hard
5	30.0	2.0	Gravel

HICKS PARKER PROPERTY

TEST HOLE G21

Location: T.7 N., R.1 W., Sec. 35, western part; left wall of St. Catherine Creek valley, 127 ft. south of G20 Drilled: March 20, 1940

Elevation: 314 ft. Water level: 22 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	3.0	3.0	Loess, brown silt, fine
			Pascagoula? formation
2	8.0	5.0	Clay, gray, very hard; Sample 1
3	12.0	4.0	Clay, gray, very hard
4	18.0	6.0	Clay, very hard; sandy
5	22.0	4.0	Clay and gravel
6	26.0	4.0	Sand and gravel
7	29.0	3.0	Gravel

John Smith Property
Outcrop G27OC

Location: T.7 N., R.2 W., Sec. 46, SE. corner; right bank of Johnson Creek about 0.4 mile from mouth of creek — Dug: March 14, 1940
Elevation: 270 ft. — Water level:

No.	Depth	Thick.	Description of strata and designations of samples
			Pascagoula formation
1	8.0	8.0	Clay, light-brown and reddish, from face of creek bank on right; overburden soil, gravel and sandstone, 10 feet. About 8 feet of clay showing.

John Smith Property
Test Hole G28

Location: T.7 N., R.2 W., Sec. 46, SE. part; right side of valley of Johnson Creek, tributary of Clear Creek, 0.4 mile from mouth of Johnson Creek; about 450 ft. northeast of G27OC — Drilled: March 12, 1940
Elevation: 293.5 ft. — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	3.3	3.3	Soil, loessial
			Pascagoula formation
2	6.3	3.0	Clay, blue; Sample 1
3	9.3	3.0	Clay, light-brown
4	23.7	14.4	Clay, yellow and gray

John Smith Property
Test Hole G29

Location: T.7 N., R.2 W., Sec. 46, SE. part; east 561 ft. up hill from G28
Drilled: March 13, 14, 15, 16, 1940
Elevation: 331 ft. — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	2.5	2.5	Soil
			Loess formation
2	4.5	2.0	Loess, brown silt, fine
			Pascagoula formation
3	19.5	15.0	Clay, light-yellow
4	27.0	7.5	Clay, light-gray
5	40.0	13.0	Clay, gray and blue
6	52.0	12.0	Clay, light-blue; Sample 1

JACOB JOHNSON PROPERTY

TEST HOLE G30

Location: T.7 N., R.2 W., Sec. 46 or 47, SE. 46 or NE. 47; some 600 ft. up stream from G27OC above small branch of Johnson Creek from left

Drilled: March 11, 12, 13, 1940

Elevation: 328 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	13.0	13.0	Loess, brown silt
			Citronelle formation
2	15.0	2.0	Clay, light-brown; gravel
			Pascagoula formation
3	27.0	12.0	Clay, gray; Sample 1
4	28.0	1.0	Clay, gray

JACOB JOHNSON PROPERTY

TEST HOLE G31

Location: T.7 N., R.2 W., Sec. 46 or 47, SE. 46 or NE. 47; 600 ft. or more west of G27OC

Drilled: March 12, 14, 1940

Elevation: 334 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent and Loess formations
1	5.0	5.0	Soil, and loess, brown silt
			Citronelle formation
2	7.4	2.4	Clay, red, and gravel and sand
			Pascagoula formation
3	9.2	1.8	Clay, grayish-brown sandy
4	23.0	13.8	Clay, grayish-brown sandy; Sample 1
5	32.0	9.0	Clay, grayish-brown sandy
6	41.5	9.5	Clay, light-blue; Sample 2

Wallace Ratcliff Property

Test Hole G32

Location: T.7 N., R.2 W., Sec. 47 or 62, southern part of Sec. 47 or northeastern part of Sec. 62; north bank of right fork of Clear Creek above old Highway 22 bridge, at old logging camp site, 300 ft above mouth of fork

Drilled: April 8, 1940

Elevation: 275 ft. Water level: 14 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.5	1.5	Soil
			Pascagoula formation
2	6.0	4.5	Clay, brown and gray; Sample 1
3	8.0	2.0	Clay, brown and gray
4	9.0	1.0	Clay, light-yellow
5	11.5	2.5	Clay, and brown sand
6	14.0	2.5	Sand, white; water

Wallace Ratcliff Property

Test Hole G33

Location: T.7 N., R.2 W., Sec. 47, southern part; south bank of right fork of Clear Creek, 210 ft. from confluence S. 55° E. Drilled April 5, 6, 8, 1940

Elevation: 289.5 ft. Water level: 48 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	4.8	4.8	Loess, brown silt
			Citronelle formation
2	6.8	2.0	Sand, red, and clay, red
			Pascagoula formation
3	11.0	4.2	Clay, light-gray, and clay, red; Sample 1
4	12.8	1.8	Clay, light-gray, and clay, red
5	24.0	11.2	Clay, light-gray; Sample 2
6	29.8	5.8	Clay, light-gray
7	33.3	3.5	Clay, light-blue; Sample 3
8	37.3	4.0	Clay, light-purple; Sample 4
9	39.3	2.0	Clay, reddish-gray
10	48.3	9.0	Clay, yellow and gray

WALLACE RATCLIFF PROPERTY

TEST HOLE G34

Location: T.7 N., R.2 W., Sec. 62, NE. part; about 225 ft. S. 15° E. of bend of Creek, first right branch of Clear Creek above Highway 84, some 600 ft. SE. of G32 Drilled: April 5, 6, 8, 9, 1940

Elevation: 327 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil
			Loess formation
2	7.0	6.5	Silt, brown; loess
			Pascagoula formation
3	8.0	1.0	Clay, brownish-gray
4	15.2	7.2	Clay, brownish-gray; Sample 1
5	22.5	7.3	Clay, brownish-gray
6	24.0	1.5	Clay, dark-blue
7	32.0	8.0	Clay, dark-blue; Sample 2
8	42.3	10.3	Clay, dark-blue
9	43.5	1.2	Sand, brown clayey
10	58.5	15.0	Clay, blue, mixed with brown

WALLACE RATCLIFF PROPERTY

TEST HOLE G35

Location: T.7 N., R.2 W., Sec. 62, NE. corner; on left bank of right fork of Clear Creek above old Highway 22 bridge, about 0.3 mile up stream from junction of forks Drilled: April 8, 9, 1940

Elevation: 283.5 ft. Water level: 16 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent alluvium
1	6.0	6.0	Sand, gravel and clay
			Pascagoula formation
2	14.0	8.0	Clay, brown and gray
3	16.0	2.0	Clay, gray, and water
4	23.0	7.0	Clay, gray; Sample 1
5	26.0	3.0	Clay, gray, and water

SOLITARY VALLEY PLANTATION

TEST HOLE G36

Location: T.7 N., R.2 W., Sec. 88 ?, eastern part; on left bank of Solitary Valley Creek, 0.5 mile below creek crossing of farm road

Drilled: Sept. 20, 21, 1939

Elevation: 180 ft. Water level: 37 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	10.0	10.0	Loess; fine-brown silt
			Citronelle formation
2	12.0	2.0	Gravel, coarse
			Hattiesburg? formation
3	26.0	14.0	Clay, light-blue, hard; Sample 1
4	30.0	4.0	Clay, light-brown
5	34.0	4.0	Sand and gravel
6	37.0	3.0	Clay, heavy light-blue
7	39.0	2.0	Gravel and water

SOLITARY VALLEY PLANTATION

TEST HOLE G37

Location: T.7 N., R.2 W., Sec. 12, southeastern corner; about 325 ft. down stream from farm road crossing, left bank of creek, some 225 ft. from creek bed and 37 ft. above it

Drilled: Sept. 19, 20, 1939

Elevation: 197 ft. Water level: 35-41 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	25.0	25.0	Loess, light-brown fine silt
			Pascagoula formation
2	27.0	2.0	Clay, brown sandy
3	32.0	5.0	Clay, gray stiff, little or no sand; Sample 1
4	35.0	3.0	Clay, gray sandy with iron streaks
5	41.0	6.0	Sand, light-brown, and water
6	44.0	3.0	Sand, greenish-blue
			Hattiesburg? formation
7	49.0	5.0	Clay, blue sandy

Solitary Valley Plantation

Test Hole G39

Location: T.6 N., R.2 W., Sec. 11, northern part; east bank of southern branch of Solitary Valley Creek about 0.5 mile south of Liberty Road, and 1170 ft. above mouth of branch Drilled: Sept. 18, 19, 20, 1939

Elevation: 215 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.2	5.2	Loess, brown, fine silt
			Pascagoula formation
2	6.2	1.0	Clay, grayish brown
3	15.3	9.1	Clay, grayish-red, or gray streaked and splotched with red; Sample 1
4	21.5	6.2	Clay, gray, streaked and splotched with red
5	22.0	0.5	Sand, clayey, brown
6	23.7	1.7	Sand, gray, clayey

Solitary Valley Plantation

Test Hole G40

Location: T.7 N., R.2 W., Sec. 85 or 89, northern part of Sec. 89 or southern part of Sec. 85; left bank of southern tributary of Solitary Valley Creek, 600 ft. above mouth of tributary Drilled: Sept. 27, 1939

Elevation: 219 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
	6.0	6.0	Loess; brown silt
			Citronelle formation
	11.0	5.0	Sand, brown
			Pascagoula formation
	22.0	11.0	Clay, light-gray; Sample 1
	24.0	2.0	Clay, light-blue and red; Sample 2
	27.0	3.0	Clay, light

Solitary Valley Plantation

Test Hole G41

Location: T.6 N., R.2 W., Sec. 11 ?, northern part; east bank of southern tributary of Solitary Valley Creek, 300 ft. above G39

Drilled: Sept. 19, 20, 1939

Elevation 206 ft. Water level: 22 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
	4.0	4.0	Loess, red-brown
			Citronelle? formation
	4.5	0.5	Sand, yellow, coarse
			Pascagoula formation
	9.3	4.8	Clay, blue with some yellow
	15.0	5.7	Clay, soft, light-yellow; Sample 1
	24.7	9.7	Clay, gray, soft
	27.0	2.3	Clay and sand, clay soft, blue
	33.0	6.0	Clay, green, soft

Solitary Valley Plantation

Test Hole G42

Location: T.6 N., R.2 W., Sec. 11 ?, northern part; west bank of tributary of Solitary Valley Creek from south, 480 ft. above G39

Drilled: Sept. 22, 25, 1939

Elevation: 211 ft. Water level: 22.3 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.0	8.0	Clay, red (loess); reddish-brown fine silt
			Citronelle? formation
2	10.5	2.5	Sand and clay, yellow and brown, with some gravel
			Pascagoula formation
3	29.0	18.5	Clay, blue; Sample 1
4	32.8	3.8	Clay, blue

SOLITARY VALLEY PLANTATION

TEST HOLE G44

Location: T.6 N., R.2 W., Sec. 58 ?, NW. part; north bank of main Solitary Valley Creek, 0.7 mile from Liberty Road, 217 ft. up stream from G43

Drilled: Sept. 21, 22, 25, 1939

Elevation: 199 ft. Water level: 23.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	1.2	1.2	Loessial soil; loam
			Loess formation
	6.2	5.0	Loess, brown, fine silt
			Pascagoula formation
	7.6	1.4	Sand, gray; indurated at outcrop to a friable sandstone
	9.6	2.0	Clay, brown
	28.6	19.0	Clay, gray mottled with red; Sample 1

SOLITARY VALLEY PLANTATION

TEST HOLE G45

Location: T.7 N., R.2 W., Sec. 58, 85, or 89; north bank of main Solitary Valley Creek 0.5 mile south of Liberty Road, at mouth of branch, 50 ft. from main creek and 25 ft. from branch

Drilled: Sept. 21, 22, 25, 1939

Elevation: 198 ft. Water level: 27 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
	2.0	2.0	Loess, fine brown silt
			Citronelle formation
	6.3	4.3	Clay, gray
	10.5	4.2	Sand and gravel
	12.0	1.5	Clay, gray, and gravel
	12.5	0.5	Sand, heavy, red, coarse
			Pascagoula formation
	18.0	5.5	Clay, greenish-gray, very compact; Sample 1
	21.5	3.5	Clay, gray, very compact; Sample 2
	23.0	1.5	Clay, blue, soft
	26.5	3.5	Sand, quick

SOLITARY VALLEY PLANTATION

TEST HOLE G46

Location: T.7 N., R.2 W., Sec. 10 or 58, NE. 10 or S. 58; north bank main Solitary Valley Creek, a little up stream from G49

Drilled: Sept. 27, 28, 1939

Elevation: 217 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
	4.0	4.0	Loess, brown
			Pascagoula formation
	19.0	15.0	Clay, grayish-yellow
	25.0	6.0	Clay, blue and yellow; Sample 1
	28.0	3.0	Clay, gray, mottled with red; Sample 2

GREEN PROPERTY ?

TEST HOLE G50

Location: T.6 N., R.2 W., Sec. 8, NW. part; left bank of ravine some 600 ft. from mouth of ravine at Solitary Valley Creek

Drilled: Oct. 2, 3, 19, 20, 1939

Elevation: 227 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	4.8	4.8	Loess, (brown silt)
2	6.1	1.3	Loess, yellow
			Pascagoula formation
3	8.7	2.6	Clay, gray; Sample 1
4	9.2	0.5	Clay, gray
5	20.0	10.8	Clay, gray, streaked with light-red; Sample 2

GREEN PROPERTY

TEST HOLE G51

Location: T.7 N., R.2 W., Sec. 10, eastern part; north bank of Solitary Valley Creek 300 ft. below G50 Drilled: Oct. 2, 3, 1939

Elevation: 234 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	4.0	4.0	Loess, brown
			Pascagoula formation
2	12.0	8.0	Clay, gray
3	17.0	5.0	Clay, bluish-gray, hard
4	28.0	11.0	Clay, grayish-yellow; Sample 1
5	32.0	4.0	Clay, gray mottled with red; Sample 2
6	34.0	2.0	Clay, gray streaked with red, hard
7	35.5	1.5	Clay, blood-red, hard
8	39.8	4.3	Clay, reddish-gray

SOLITARY VALLEY PLANTATION

TEST HOLE G57

Location: T.6 N., R.2 W., Sec. 11, northern part; north bank of south tributary of Solitary Valley Creek 150 ft. south of G39 and across small ravine from it Drilled: Sept. 26, 27, 1939

Elevation: 220 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.0	5.0	Clay, red (from loess)
			Pascagoula formation
2	9.2	4.2	Sand and clay
3	10.5	1.3	Clay, light gray
4	13.0	2.5	Clay, rusty red
5	17.8	4.8	Clay, rusty; Sample 1

HICKS PARKER PROPERTY

TEST HOLE G58

Location: T.7 N., R.1 W., Sec. 20 or 35; about 0.3 mile below head of north fork of Upper St. Catherine Creek, 60 ft. east of fork, 360 ft. west of G59

Drilled: May 17, 1940

Elevation: 332 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.8	8.8	Loess; brown silt
			Citronelle formation
2	11.0	2.2	Gravel and sand
			Pascagoula formation
3	18.0	7.0	Clay, light-gray; Sample 1
4	26.5	8.5	Light sand and clay

HICKS PARKER PROPERTY

TEST HOLE G59

Location: T.7 N., R.1 W., Sec. 20 or 35; about 0.3 mile west of Stanton Road, on south bank of north headwater fork of St. Catherine Creek, 102 ft. south of fork

Drilled: May 17, 20, 1940

Elevation: 330 ft. Water level: 25 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	2.8	2.8	Loess; brown silt
			Pascagoula formation
2	5.0	2.2	Clay, yellowish-gray
3	20.0	15.0	Clay, bluish-gray; Sample 1
4	21.0	1.0	Clay, bluish-gray
5	25.0	4.0	Clay, gray; water

WALLACE RATCLIFF PROPERTY

TEST HOLE G60

Location: T.7 N., R.2 W., Sec. 62, NE. part; on right bank of right fork of Clear Creek, 0.5 mile east of old bridge — Drilled: April 6, 1940

Elevation: 320 ft. — Water level: 26 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	6.5	6.5	Loess, brown
			Citronelle formation
2	10.0	3.5	Sand, white
3	12.0	2.0	Sand, red-brown
4	18.0	6.0	Sand and clay mixed
			Pascagoula formation
5	20.0	2.0	Clay, gray, hard
6	26.0	6.0	Clay, gray hard; Sample 1
7	30.0	4.0	Clay, blue hard
8	32.0	2.0	Sand, blue, wet

WALLACE RATCLIFF PROPERTY

TEST HOLE G61

Location: T.7 N., R.2 W., Sec. 62, NE. part; on left bank of right fork of Clear Creek, south of G60 which is on opposite bank of creek, 50 ft from creek bank — Drilled: April 8, 1940

Elevation: 320 ft. — Water level: 20 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	12.0	12.0	Loess, light-brown silt
			Citronelle formation
2	16.0	4.0	Sand and gravel
3	18.0	2.0	Sand, red-brown, wet
			Pascagoula formation
4	20.0	2.0	Clay, gray, hard
5	24.0	4.0	Clay, blue, hard and wet; Sample 1
6	28.0	4.0	Clay, blue, hard and wet
7	30.0	2.0	Gravel

Wallace Ratcliff Property

Test Hole G62

Location: T.7 N., R.2 W., Sec. 62, southern part; left fork of Clear Creek, 750-900 ft. north of Mississippi Central Railroad, some 450 ft. west of creek, up slope Drilled: May 9, 1940

Elevation: 300 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	3.0	3.0	Soil
			Citronelle formation
2	5.0	2.0	Clay, gray
3	6.0	1.0	Gravel
4	8.0	2.0	Sand, red-brown
			Pascagoula formation
5	11.0	3.0	Clay, yellow
6	13.0	2.0	Clay, gray and yellow; Sample 1
7	18.0	5.0	Clay, light-gray; Sample 2
8	24.0	6.0	Clay, dark-blue, turns light-gray on exposure; Sample 3
9	30.8	6.8	Clay, dark-blue

Wallace Ratcliff Property

Test Hole G63

Location: T.7 N., R.2 W., Sec. 62, southern part; on left fork of upper Clear Creek, about 0.3 mile north of Mississippi Central Railroad

Drilled: May 9, 1940

Elevation: 315 ft. Water level: 12 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	4.0	4.0	Loess, brown silt
			Citronelle formation
2	9.0	5.0	Sand, red, brown, coarse
3	12.0	3.0	Clay, gray and sand, wet
			Pascagoula formation
4	14.0	2.0	Clay, yellow, wet
5	20.0	6.0	Clay, blue, turns green on exposure to air; Sample 1
6	22.0	2.0	Clay, blue, and sand
7	29.0	7.0	Sand, blue, wet

Wallace Ratcliff Property

Test Hole G64

Location: T.7 N., R.2 W., Sec. 62, southern part; east bank of Clear Creek 750 ft. north of Mississippi Central Railroad Drilled: May 8, 9, 1940
Elevation: 310 ft. Water level: 33 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	1.5	1.5	Loess; brown silt
			Citronelle formation
2	3.0	1.5	Sand and gravel
			Pascagoula formation
3	4.0	1.0	Clay, grayish-brown
4	10.0	6.0	Clay, yellowish-gray; Sample 1
5	15.0	5.0	Clay, yellowish-gray
6	32.0	17.0	Clay, bluish-gray
7	33.0	1.0	Clay, brown; water
8	36.0	3.0	Clay, blue

George Hightower Property

Test Hole G65

Location: T.7 N., R.2 W., Sec. 18; Cedar Grove Church on tributary of Whitens Creek, between two branches, 450 ft. from fork of branch
Drilled: May 1, 2, 1940
Elevation: 305 ft. Water level: 36 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	4.0	4.0	Soil and subsoil
			Loess formation
2	16.0	12.0	Loess, brown silt
			Pascagoula formation
3	33.0	17.0	Clay, light-gray to brown and red; Sample 1
4	36.0	3.0	Clay, brown and red; water

Hicks Parker Property

Test Hole G66

Location: T.7 N., R.1 W., Sec. 20; right headwater fork of main St. Catherine Creek about 0.3 mile west of Stanton-Fenwick road, 90 ft. south of creek bed Drilled: May 17, 1940

Elevation: 328 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	4.6	4.6	Loess; brown silt
			Pascagoula formation
2	5.9	1.3	Clay, medium-brown
3	15.9	10.0	Clay, light-gray; Sample 1
4	17.3	1.4	Clay, light-gray, resting on light-gray sandstone

George Hightower Property

Test Hole G67

Location: T.7 N., R.1 W., Sec. 14; about 300 ft. east of Stanton-Fenwick Road on ridge SE. of Cedar Grove Church Drilled: April 20, 1940

Elevation: 375 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.0	5.0	Loess, yellowish
2	13.3	8.3	Loess, yellowish; Sample 1
3	19.0	5.7	Loess, as above

George Hightower Property

Test Hole G68

Location: T.7 N., R.1 W., Sec. 14; about 0.3 mile SE. of Cedar Grove Church in valley of branch of Whitens Creek Drilled: April 23, 25, 26, 1940

Elevation: 290 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Citronelle formation
1	10.5	10.5	Sand, grayish-yellow, streaked with clay
			Pascagoula formation
2	15.0	4.5	Clay, gray streaked with red; Sample 1
3	18.4	3.4	Clay, gray streaked with red; Sample 2

Hicks Parker Property

Test Hole G69

Location: T.7 N., R.1 W., Sec. 20; 186 ft. S. 40° W. of place where wire fence crosses creek, on north bank of upper right fork of St. Catherine Creek

Drilled: May 21, 1940

Elevation: 335 ft. Water level: 31 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	14.2	14.2	Loess
			Citronelle formation
2	16.7	2.5	Clay, brown, and gravel
			Pascagoula formation
3	17.0	.3	Clay, purplish-gray
4	22.0	5.0	Clay, purplish-gray; Sample 1
5	31.6	9.6	Clay, gray and purple

George Hightower Property

Test Hole G70

Location: T.7 N., R.1 W., Sec. 18; 765 ft. from headwater branch of Whitens Creek, left side of branch, 0.5 mile south of Cedar Grove Church

Drilled: May 1, 2, 1940

Elevation: 335 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	16.0	16.0	Loess; brown silt
			Pascagoula formation
2	18.0	2.0	Clay, light-gray mixed with lime; brown spotted; contains very fine sand; Sample 1
3	32.0	14.0	Clay, light-gray; Sample 2

George Hightower Property

Test Hole G71

Location: T.7 N., R.1 W., Sec. 14, left side of branch of Whitens Creek, 0.3 mile southeast of Cedar Grove Church — Drilled: April 27, 1940

Elevation: 315 ft. — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	7.5	7.5	Loess; brown silt
			Citronelle formation
2	11.7	4.2	Sand, gray
			Pascagoula formation
3	13.5	1.8	Clay, yellowish-gray
4	27.0	13.5	Clay, gray and gray mottled with red; Sample 1
5	32.0	5.0	Clay, gray

George Armstrong Property

Test Hole G72

Location: T.7 N., R.1 W., Sec. 22, eastern part; 210 ft. west of Walker Springs Branch, near wreck of house — Drilled: May 27, 28, 1940

Elevation: 299 ft. — Water level: 12 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Citronelle formation
1	7.0	7.0	Sand, red, and gravel
			Pascagoula formation
2	12.0	5.0	Clay, gray and yellow; Sample 1
3	14.0	2.0	Sand, gray, hard and wet
4	24.0	10.0	Clay, gray, hard and wet
5	26.0	2.0	Clay and sand, hard and wet
6	30.0	4.0	Clay, purple, little sand; wet
			Hattiesburg? formation
7	36.0	6.0	Clay, blue, hard and wet

George Armstrong Property

Test Hole G73

Location: T.7 N., R.1 W., Sec. 8; on left of Walker Springs Branch, a tributary of Whitens Creek, 8 ft. from branch at sharp bend 0.3 mile above mouth of branch Drilled: May 29, June 4, 1940

Elevation: 285 ft. Water level: 28 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Citronelle formation
1	4.5	4.5	Sand and gravel
			Pascagoula formation
2	15.0	10.5	Clay, light-yellow and red; Sample 1
3	18.0	3.0	Clay, gray, sandy
4	24.5	6.5	Clay, gray mottled with red; Sample 2
5	41.0	16.5	Clay, reddish; very wet, caving

George Armstrong Property

Test Hole G75

Location: T.7 N., R.1 W., Sec. 8, southern part; in bed of Whitens Creek, 150 ft. below crossing of old logging road at the T. Whitley land, 0.3 mile above mouth of Walker Springs Branch Drilled: June 6, 7, 1940

Elevation: 258 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	4.0	4.0	Gray sand and gravel
			Pascagoula formation
2	13.5	9.5	Clay, gray mottled with brown; wet
3	25.0	11.5	Clay, gray, hard; Sample 1
4	26.0	1.0	Clay and sand, hard
5	27.0	1.0	Clay, blue, hard, little sand
6	33.3	6.3	Clay, gray, hard
			Hattiesburg? formation
7	35.0	1.7	Clay, black, sandy
8	38.0	3.0	Clay, gray, hard

GEORGE ARMSTRONG PROPERTY

TEST HOLE G76

Location: T.7 N., R.1 W., Sec. 8, southern part; on right bank of Walker Springs Branch
Drilled: May 27, 28, 1940
Elevation: 300 ft.
Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	14.5	14.5	Loess; brown silt
			Citronelle formation
2	15.9	1.4	Clay and gravel; brown, and brown sand
			Pascagoula formation
3	26.1	10.2	Clay, steel-gray
4	28.4	2.3	Clay, gray, and reddish-brown
5	29.4	1.0	Clay shale, gray
6	44.4	15.0	Clay, grayish-brown; Sample 1
7	47.4	3.0	Clay, grayish-brown
8	56.4	9.0	Clay, light-blue and gray

GEORGE ARMSTRONG PROPERTY

TEST HOLE G77

Location: T.7 N., R.1 W., Sec. 22, NE. part, on Walker Springs Branch, tributary of Whitens Creek
Drilled: June 4, 5, 1940
Elevation: 300 ft.
Water level: 29 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.5	1.5	Soil
			Loess formation
2	3.8	2.3	Loess; brown silt
			Citronelle formation
3	7.8	4.0	Gravel and sand
			Pascagoula formation
4	16.9	9.1	Clay, red and purple
5	29.1	12.2	Clay, gray with red streaks; Sample 1

George Armstrong Property

Test Hole G78

Location: T.7 N., R.1 W., Sec. 22; on Walker Springs Branch, between forks and 126 ft. from forks of branch, about 0.5 mile above mouth of branch

Drilled: June 6, 1940

Elevation: 300 ft. Water level: 28.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	0.8	0.8	Loess; brown silt
			Citronelle formation
2	2.0	1.2	Gravel
			Pascagoula formation
3	6.3	4.3	Clay, light yellow
4	21.3	15.0	Clay, light gray; Sample 1
5	28.5	7.2	Clay, light blue

George Armstrong Property

Test Hole G80

Location: T.7 N., R.1 W., Sec. 8; in bed of Walker Springs Branch, 0.4-0.5 mile above its mouth Drilled: May 28, 29, 1940

Elevation: 281 ft. Water level: 5.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Pascagoula formation
1	5.8	5.8	Clay, light-gray, streaked with red; Sample 1
2	12.4	6.6	Clay, light-gray streaked with red

George Armstrong Property

Test Hole G81

Location: T.7 N., R.1 W., Sec. 8, western part; on west side of Whitens Creek at mouth of Walker Springs Branch Drilled: June 6, 1940

Elevation: 265 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	3.4	3.4	Clay, gray, and sand
2	7.5	4.1	Clay, dark grayish-brown, red spots
			Pascagoula formation
3	19.2	11.7	Clay, light-gray with brown streaks and spots; Sample 1

George Armstrong Property

Test Hole G82

Location: T.7 N., R.1 W., Sec. 8 or 22; Walker Springs Branch, east bank of left fork, about 0.5 mile above mouth of branch Drilled: June 6, 1940

Elevation: 305 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.5	1.5	Soil
			Pascagoula formation
2	3.8	2.3	Clay, light-brown and light-gray; Sample 1
3	10.2	6.4	Clay, light-gray; Sample 2
4	11.0	0.8	Clay, very dark-gray, almost black

George Armstrong Property

Test Hole G83

Location: T.7 N., R.1 W., Sec. 8; 300 ft. east of Walker Springs Branch and 0.4 mile above its mouth Drilled: May 22, 25, 27, 1940

Elevation: 313 ft. Water level: 52 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	6.7	6.7	Loess; brown silt
			Pascagoula formation
2	26.7	20.0	Clay, gray, and gray mottled with red; Sample 1
3	38.0	11.3	Clay, mottled
4	43.0	5.0	Clay, grayish-blue
5	54.3	11.3	Clay, bluish-brown
6	56.9	2.6	Clay, greenish-gray
7	58.0	1.1	Clay, reddish-gray
8	60.0	2.0	Clay, brown and gray mixed

George Armstrong Property

Test Hole G84

Location: T.7 N., R.1 W., Sec. 8, western part; on east bank of Walker Springs Branch, 900 ft above mouth of branch   Drilled: June 4, 5, 6, 1940
Elevation: 288 ft.   Water level: 50 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	15.2	15.2	Loess, brown silt and soil
			Pascagoula formation
2	17.0	1.8	Clay, reddish-brown
3	39.0	22.0	Clay, variously colored, gray, light to dark, mottled with red; blue mottled with red, and light-brown; Sample 1
4	39.6	0.6	Clay, brownish-gray
5	40.6	1.0	Clay, brownish-gray
6	42.3	1.7	Clay, greenish-gray
			Hattiesburg? formation
7	51.0	8.7	Clay, dark-gray; small seep of water
8	52.6	1.6	Clay, blue
9	62.6	10.0	Clay, brown and gray

C. W. Hazlip Property

Test Hole G85

Location: T.7 N., R.2 W., Sec. 83; Kittering Creek, 180 ft. from creek, on west bank, up hill from where logging road crosses; 1.5 miles below head of Kittering Creek   Drilled: May 14, 1940
Elevation: 287 ft.   Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation and Loess formation
1	9.0	9.0	Soil and Loess
			Citronelle formation
2	10.5	1.5	Sand, white
3	12.0	1.5	Clay, gray
4	13.0	1.0	Sand, red-brown
			Pascagoula formation
5	20.0	7.0	Clay, yellow; Sample 1
6	21.3	1.3	Clay, yellow
7	24.0	2.7	Clay, light-gray; Sample 2
8	24.7	0.7	Clay, light-gray
9	33.7	9.0	Clay, dark-blue; Sample 3

C. W. HAZLIP PROPERTY
TEST HOLE G86

Location: T.7 N., R.2 W., Sec. 83, NE. part; on left bank of left fork of Kittering Creek, 225 ft. from G87; 90 ft. from creek

Drilled: May 11, 13, 1940

Elevation: 280 ft. Water level: 25 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	7.5	7.5	Loess, brown silt
			Citronelle formation
2	8.9	1.4	Sand, reddish-brown, clayey
			Pascagoula formation
3	10.0	1.1	Clay, brownish-gray
4	15.0	5.0	Clay, brownish-gray; Sample 1
5	28.0	13.0	Clay, brownish-gray

C. W. HAZLIP PROPERTY
TEST HOLE G87

Location: T.7 N., R.2 W., Sec. 83, NE. part; bed of south fork of upper Kittering Creek; 360 ft. southeast of mouth of left tributary

Drilled: May 11, 1940

Elevation: 250 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Pascagoula formation
1	6.0	6.0	Clay, gray, mottled with red; Sample 1

WINDY HILL MANOR (STANTON PROPERTY)
TEST HOLE G88

Location: T.7 N., R.2 W., Sec. 84, S. part; left bank of creek, some 750 ft. below and N. 20° W. from bridge on Windy Hill Manor road 0.5 mile northeast of Liberty Road Drilled: April 2, 1940

Elevation: 242 ft. Water level: 28 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	9.0	9.0	Loess; brown silt
			Pascagoula formation
2	15.0	6.0	Clay, golden-brown; Sample 1
3	16.5	1.5	Clay, golden-brown
4	25.5	9.0	Clay, light-brown
5	28.0	2.5	Clay, dark-blue and green

SOLITARY VALLEY PLANTATION

TEST HOLE G89

Location: T.7 N., R.2 W., Sec. 85, southeast part; on north bank of right fork of Solitary Valley Creek, 150 ft. above ravine, 0.3 mile upstream from junction of forks, on bluff Drilled: June 1, 1940

Elevation: 200 ft. Water level: 24 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.5	5.5	Loess, light-brown silt
			Pascagoula formation
2	13.5	8.0	Clay, light-gray, yellow spots, sandy; Sample 1
3	17.0	3.5	Clay and sand, hard
4	22.5	5.5	Clay, gray, hard; Sample 2
5	24.0	1.5	Clay and sand
6	26.5	2.5	Sand, wet
7	28.0	1.5	Clay, yellow, and sand, wet
8	32.0	4.0	Sand, wet, caving

SOLITARY VALLEY PLANTATION

TEST HOLE G90

Location: T.7 N., R.2 W., Sec. 85, southeast part; on south bank of creek, east of hole No. G89 Drilled: June 3, 1940

Elevation: 195 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.3	8.3	Loess, light-brown silt
			Pascagoula formation
2	15.0	6.7	Clay, yellowish-gray; hard; Sample 1

Solitary Valley Plantation

Test Hole G91

Location: T.6 N., R.2 W., Sec. 11, northern part; west bank of southern tributary of Solitary Valley Creek, 1500 ft. above junction of forks. Same location as G42 Drilled: June 3, 1940

Elevation: 210 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	3.0	3.0	Soil, loessial, black
			Loess formation
2	11.3	8.3	Loess, dark-brown, clayey
			Citronelle formation
3	12.6	1.3	Gravel and sand
			Pascagoula formation
4	14.8	2.2	Clay, light grayish-brown; Sample 1
5	20.1	5.3	Clay, gray streaked with red; Sample 2
6	29.3	9.2	Clay, light-blue and gray; Sample 3

Solitary Valley Plantation

Test Hole G92

Location: T.7 N., R.2 W., Sec. 89, southern part; east bank of south fork of Solitary Valley Creek some 1050 ft. above junction of forks, at small ravine; same location as G39 Drilled: May 31, June 1, 3, 1940

Elevation: 215 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.3	0.3	Soil
			Loess formation
2	4.2	3.9	Loess; brown silt
			Pascagoula formation
3	8.9	4.7	Clay, gray mottled with red; sandy. Sample 1
4	10.7	1.8	Clay, gray, mottled with red; sandy. Sample 2
5	16.5	5.8	Clay, gray, mottled with red; sandy. Sample 3
6	18.1	1.6	Clay, brown, gray, mottled, sandy

SOLITARY VALLEY PLANTATION

TEST HOLE G93

Location: T.7 N., R.2 W., Sec. 89, eastern part; right fork of Solitary Valley Creek, about 0.3-0.4 mile up stream from junction of forks

Drilled: June 3, 1940

Elevation: 198 ft. Water level: 9.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Pascagoula formation
1	6.0	6.0	Clay, light-gray and red; Sample 1
2	8.1	2.1	Clay, light-brown and dark-brown
3	9.6	1.5	Clay, light-gray

SOLITARY VALLEY PLANTATION

TEST HOLE G94

Location: T.6 N., R.2 W., Sec. 58, NW. corner; about 3150 ft. east of branch leading southeast from main creek; on right bank of Solitary Valley Creek

Drilled: May 31, June 3, 1940

Elevation: 215 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	2.9	2.9	Loess; brown silt
			Citronelle formation
2	4.2	1.3	Sand, brown, and gravel
			Pascagoula formation
3	9.8	5.6	Clay, light-gray to mottled; contains some fine sand; Sample 1
4	32.0	22.2	Clay, light-gray to dark-gray or gray and red, contains some fine sand. Sample 2

Green? Property

Test Hole G95

Location: T.6 N., R.2 W., Sec. 8, northern part; 375 ft. north of G51, 10 ft. •from ravine on left bank upper Solitary Valley Creek

Drilled: Oct. 20, 1939

Elevation: 250 ft. Water level: 9 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Citronelle formation
1	3.0	3.0	Sand and gravel
			Pascagoula formation
2	14.0	11.0	Clay, blue; Sample 1
3	26.4	12.4	Clay, red and yellowish-gray; very sandy; approaches clayey sand
4	29.0	2.6	Sand, yellow

Bailey Property

Test Hole G96

Location: T.6 N., R.2 W., Sec. 47, western part; 750 ft. north of culvert at Clifford Road on east bank of Kingston Road cut Drilled: May 6, 1940

Elevation: 320 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	10.0	10.0	Loess; brown silt
			Citronelle? formation
2	23.0	13.0	Clay, gray and grayish-blue, with some yellow and gray mottled with red; some sand and small gravel. Sample 1

EVERETT RATCLIFF PROPERTY

TEST HOLE G97

Location: T.7 N., R.1 W., Sec. 50; eastern Sunnyside branch of upper Sandy Creek; 180 ft. northwest of headwater fork on west bank of branch

Drilled: June 10, 12, 13, 1940

Elevation: 309 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.8	0.8	Soil, black
			Citronelle formation
2	2.2	1.4	Sand, brown silty
			Pascagoula formation
3	4.9	2.7	Sand, yellowish-gray, clayey
4	8.3	3.4	Sand, yellowish-gray, fine
5	24.3	16.0	Clay, gray mottled with red; Sample 1
6	26.9	2.6	Clay, light-gray to bluish-gray, with pink to reddish stains. Sample 2
7	36.8	9.9	Clay, light-blue streaked with brown and purple; contains fine sand. Sample 3
8	40.8	4.0	Clay, dark-blue mixed with brown. Sample 4
9	44.0	3.2	Sand, brownish-gray, little clayey

EVERETT RATCLIFF PROPERTY

TEST HOLE G98

Location: T.7 N., R.1 W., Sec. 69, southern part; left wall of east headwater branch of Sandy Creek; 1200 ft. below G97 Drilled: June 10, 12, 1940

Elevation: 314 ft. Water level: 42 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil
			Loess formation
2	2.8	2.3	Clay, light-gray mixed with loess
			Pascagoula formation
3	27.8	25.0	Clay, gray mottled with brown; sandy; Sample 1
4	31.8	4.0	Clay, mottled with brown, about same as above. Sample 2
5	36.0	4.2	Clay, light-blue with red streaks. Sample 3
6	42.7	6.7	Clay, light-green; water at bottom

EVERETT RATCLIFF PROPERTY

TEST HOLE G99

Location: T.7 N., R.1 W., Sec. 69 or 71; left side of left headwater branch of Sandy Creek, 315 ft. south of G98 Drilled: June 10, 12, 1940

Elevation: 323 ft. Water level: 37 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.5	8.5	Loess; brown silt
			Pascagoula formation
2	13.2	4.7	Clay, brownish-gray
3	14.0	0.8	Clay, light-gray
4	17.5	3.5	Clay, brownish-gray; Sample 1
5	33.7	16.2	Clay, brown, green, gray, mottled
6	35.5	1.8	Clay, light-green
7	37.0	1.5	Sand and water

EVERETT RATCLIFF PROPERTY

TEST HOLE G100

Location: T.7 N., R.1 W., Sec. 69, southern part; on right bank of east Ratcliff fork of upper Sandy Creek Drilled: June 10, 12, 14, 1940

Elevation: 302 ft. Water level: 23.3 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.5	1.5	Soil
			Loess formation
2	7.5	6.0	Loess; light-brown silt
			Pascagoula formation
3	13.0	5.5	Clay, light-gray, brown stain
4	20.0	7.0	Clay, light-gray, yellow stain; Sample 1
5	21.1	1.1	Clay, light-brown; Sample 2
6	23.4	2.3	Clay, light-blue, and sand
7	31.6	8.2	Clay, light-blue, and wet sand

Everett Ratcliff Property

Test Hole G101

Location: T.7 N., R.1 W., Sec. 69, southern part; on right bank of east Ratcliff fork of upper Sandy Creek, 150 ft. from creek Drilled: June 12, 14, 1940
Elevation: 317 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	7.3	7.3	Loess; light-brown silt
			Pascagoula formation
2	11.8	4.5	Clay, light-gray, mixed with sand
3	15.3	3.5	Clay, light-gray mixed with red; Sample 1

Everett Ratcliff Property

Test Hole G102

Location: T.7 N., R.1 W., Sec. 71, NW. part; on right of east fork of Sandy Creek on side of hill 300 ft. from branch Drilled: June 12, 1940
Elevation: 309 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.5	8.5	Loess, light-brown
			Citronelle formation
2	12.0	3.5	Light-brown sand, and gravel
3	16.3	4.3	Sand, very light-gray or light-yellow; clayey
			Pascagoula formation
4	20.6	4.3	Clay, gray; Sample 1
5	26.9	6.3	Sand, gray
6	29.2	2.3	Clay and red sand
7	35.9	6.7	Clay, red; Sample 2
8	37.9	2.0	Clay, gray

Everett Ratcliff Property

Test Hole G103

Location: T.7 N., R.1 W., Sec. 71; on west side of left Ratcliff fork of Sandy Creek; 500 ft. from branch   Drilled: June 13, 14, 1940
Elevation: 314 ft.   Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.0	8.0	Loess, light-brown
			Citronelle formation
2	12.3	4.3	Sand, yellow
			Pascagoula formation
3	24.0	11.7	Clay, sandy
4	28.5	4.5	Clay, red and gray; Sample 1
5	30.3	1.8	Clay, yellow
6	33.5	3.2	Clay, red; very hard
7	45.0	11.5	Clay, gray, hard; sand
8	47.0	2.0	Gravel

Everett Ratcliff Property

Test Hole G104

Location: T.7 N., R.1 W., Sec. 51; on right side of right fork of western Ratcliff tributary of Sandy Creek, on ridge under oak tree
Drilled: June 18, 19, 20, 1940
Elevation: 321 ft.   Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.7	5.7	Loess; light-brown silt
			Pascagoula formation
2	8.3	2.6	Clay light-gray, mixed with sand
3	12.1	3.8	Clay, light-gray mixed with red; Sample 1
4	18.0	5.9	Clay, light-gray, mixed with red
5	28.2	10.2	Clay, gray mixed with little red

Everett Ratcliff Property

Test Hole G105

Location: T.7 N., R.1 W., Sec. 66, southern part; 100 ft. from branch, 600 ft. from the Cade house on path to branch from house; 0.3 mile south of U. S. Highway 84 Drilled: Aug. 12, 13, 14, 15, 1940

Elevation: 324 ft. Water level: 48 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	1.5	1.5	Loess; light-brown silt
			Pascagoula formation
2	18.0	16.5	Clay, light-brown, sandy, very hard
3	32.2	14.2	Clay, gray, very hard; Sample 1
4	39.4	7.2	Clay, bluish-gray mottled with red, hard
5	46.9	7.5	Clay, gray tinted with red
6	47.4	0.5	Sand, white
7	51.1	3.7	Clay, sandy
			Hattiesburg? formation
8	52.9	1.8	Clay, dark-brown; gray when dry
9	75.9	23.0	Clay, blue, hard; dries light bluish-gray; brown stained, sandy

Everett Ratcliff Property

Test Hole G106

Location: T.7 N., R.1 W., Sec. 66, eastern part; under little pine tree on right of trail from the Cade house Drilled: Aug. 13, 14, 15, 1940

Elevation: 313 ft. Water level: 45.7 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	1.0	1.0	Loess, light-brown silt
			Pascagoula formation
2	3.0	2.0	Clay, light-gray
3	9.2	6.2	Clay, dark-gray
4	18.2	9.0	Clay, gray and brown; Sample 1
5	24.2	6.0	Clay, light-gray somewhat sandy
6	29.2	5.0	Clay, light-brown streaked with gray
7	33.5	4.3	Clay, dark-brown sandy; Sample 2
8	39.7	6.2	Sand, light-gray silty
9	41.7	2.0	Sand, blue, and clay
			Hattiesburg? formation
10	45.7	4.0	Clay, dark-gray

EVERETT RATCLIFF PROPERTY

TEST HOLE G107

Location: T.7 N., R.1 W., Sec. 67, northern part; 900 ft. southeast of the Cade house 120 ft. from intersection of road Drilled: Aug. 13, 14, 1940
Elevation: 318 ft Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Citronelle formation
1	2.4	2.4	Sand, red
2	4.6	2.2	Sand and gravel
			Pascagoula formation
3	6.6	2.0	Clay, light-gray mixed with red
4	19.1	12.5	Clay, light-gray and brown; Sample 1
5	24.1	5.0	Clay, light-brown and red
6	26.3	2.2	Clay, Light-blue mixed with red
7	34.5	8.2	Clay, light-blue mixed with green
8	37.0	2.5	Clay, dark-brown; dark-green when fresh
9	40.2	3.2	Clay, light-blue
			Hattiesburg? formation
10	53.2	13.0	Clay, green, hard

EVERETT RATCLIFF PROPERTY

TEST HOLE G108

Location: T.7 N., R.1 W., Sec. 66, NE. part; 195 ft. N. 65° E. of G105
Drilled: Aug. 12, 13, 14, 15, 1940
Elevation: 319 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.2	5.2	Loess; light-brown silt
			Pascagoula formation
2	13.0	7.8	Clay, mottled gray and red
3	18.4	5.4	Clay, grayish, brown
4	23.8	5.4	Clay, light-bluish-gray with faint red tint
5	34.2	10.4	Clay, light-blue with faint red tint; Sample 1
6	38.5	4.3	Clay, brown
			Hattiesburg? formation
7	63.2	24.7	Clay, black
8	68.0	4.8	Clay, brownish-gray with olive-green tint
9	70.0	2.0	Sand, blue
10	74.2	4.2	Clay, brown; dark brownish-gray when dry

E. Blanchard Property

Test Hole G109

Location: T.7 N., R.1 W., Sec. 46, central part; 10 ft. from road under two pine trees on side of road near bayou across from cornfield

Drilled: July 5, 1940

Elevation: 320 ft. Water level: 18 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	8.5	8.5	Loess, light-brown silt, and sand
			Pascagoula formation
2	11.5	3.0	Clay, gray, containing lime lumps; Sample 1
3	20.0	8.5	Clay, sandy, wet lower part
4	24.5	4.5	Clay, gray, very wet
5	28.3	3.8	Clay, sandy, very wet
6	32.0	3.7	Clay, gray, very wet
7	37.5	5.5	Clay and sand, very wet

E. Blanchard Property

Test Hole G110

Location: T.7 N., R.1 W., Sec. 46, central part; 210 ft. N. 80° W. of G109

Drilled: July 5, 1940

Elevation: 324 ft. Water level: 21 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	2.5	2.5	Loess, light-brown
			Pascagoula formation
2	13.2	10.7	Clay, light-gray mixed with brown; Sample 1
3	14.6	1.4	Clay, light-gray mixed with sand
4	19.8	5.2	Clay, light-gray mixed with brown
5	21.1	1.3	Clay, light-gray mixed with brown
6	29.7	8.6	Clay, light-gray

E. Blanchard Property

Test Hole G111

Location: T.7 N., R.1 W., Sec. 46; 20 ft. S. 75° E. of road leading from U. S. Highway 84 about 0.5 mile distant — Drilled: July 5, 1940

Elevation: 342 ft. — Water level: 29.2 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	3.3	3.3	Loess; light-brown silt
			Pascagoula formation
2	7.8	4.5	Clay, red sandy
3	12.0	4.2	Clay, red and brown mottled
4	25.2	13.2	Clay light-gray; Sample 1
5	29.2	4.0	Clay, gray; water
6	36.0	6.8	Clay, grayish-brown

H. Carter Property

Test Hole G112

Location: T.6 N., R.1 W., Sec. 45, eastern part; on hill 300 ft. from road on north side; 300 ft. northeast of barnyard — Drilled: July 6, 1940

Elevation: 265 ft. — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	5.5	5.5	Loess, brown silt
			Citronelle formation
2	12.0	6.5	Sand, yellow
3	16.0	4.0	Sand and gravel
			Pascagoula? formation
4	22.0	6.0	Clay, sand; Sample 1

H. CARTER PROPERTY

TEST HOLE G113

Location: T.6 N., R.1 W., Sec. 45, eastern part; 1350 ft. N. 35° W. of G112, N. 80° E. of gate
Drilled: July 2, 6, 1940
Elevation: 303 ft.
Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.0	1.0	Loessial soil
			Citronelle formation
2	3.3	2.3	Sand, red
3	6.1	2.8	Clay, light-gray, and red sand
			Pascagoula? formation
4	14.3	8.2	Clay, light-gray, mixed with brown; Sample 1
5	24.6	10.3	Clay, light-gray mixed with light-brown
6	29.6	5.0	Clay, fine-gray mixed with brown; contains very fine sand

H. CARTER PROPERTY

TEST HOLE G114

Location: T.6 N., R.1 W.; Sec. 45; 390 ft. N. 45° E. of log cabin, south of the Carter house
Drilled: July 2, 1940
Elevation: 250 ft.
Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	7.8	7.8	Loess; brown silt
			Citronelle formation
2	11.8	4.0	Clay, yellowish-gray, sandy
3	12.7	0.9	Clay and sand
4	26.8	14.1	Clay, light-gray; Sample 1
5	38.7	11.9	Sand

H. Carter Property

Test Hole G115

Location: T.6 N., R.1 W., Sec. 45, eastern part; 1236 ft. N. 25° E. of bridge, 0.3 mile east of the Carter house on creek Drilled: July 6, 1940

Elevation: 263 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	2.5	2.5	Loess; brown silt
			Pascagoula? formation
2	5.0	2.5	Clay, gray
3	19.7	14.7	Clay, grayish-brown; Sample 1
4	24.8	5.1	Clay, rainbow
5	32.8	8.0	Clay, gray

George Hightower Property

Test Hole G118

Location: T.7 N., R.1 W., Sec. 14, NW. part; 1050 ft. west of Stanton-Fenwick road, 1 mile south from the Hightower store at Stanton

Drilled: July 19, 1940

Elevation: 306 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	4.0	4.0	Loess, light-brown silt
			Pascagoula formation
2	6.3	2.3	Clay, dark-brown
3	10.6	4.3	Clay, light-gray; Sample 1
4	26.0	15.4	Clay, dark-gray mixed with red; Sample 2

R. N. RATCLIFF PROPERTY

TEST HOLE G119

Location: T.7 N., R.1 W., Sec. 65 or 74; 705 ft. N. 70° E. of the Williams house at foot of hill under big oak tree Drilled: Aug. 20, 1940

Elevation: 272 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Loess formation
1	3.0	3.0	Loess; brown silt
			Pascagoula formation
2	17.6	14.6	Clay, gray; Sample 1
			Hattiesburg? formation
3	20.6	3.0	Clay, black and gray; light-gray, with black stains; very sandy, approaching a clayey sand
4	25.4	4.8	Clay, mottled light-brown and gray; contains fine sand
5	31.4	6.0	Clay, light-brown
6	32.5	1.1	Sand, blue and brown; fine
7	36.5	4.0	Sand, blue

HICKS PARKER PROPERTY

TEST HOLE G120

Location: T.7 N., R.1 W., Sec. 35, central part; about 1.2 mile below the head of the main headwater branch of St. Catherine Creek

Drilled: Aug. 22, 1940

Elevation: 280 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Pascagoula formation
	12.0	12.0	Clay, gray, mottled with red; Sample 1

Hicks Parker Property

Outcrop G500OC

Location: T.7 N., R.1 W., Sec. 35, west central part; cliff 300 ft. above mouth of southernmost headwater tributary of St. Catherine Creek

Dug: March 19, 1940

Elevation: 273 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	10.0	10.0	*Pascagoula formation* Clay, light-gray to dark-gray, mottled with red iron oxide stains. To level of creek bed; Sample OC

E. Blanchard Property

Outcrop G501OC

Location: T.7 N., R.1 W., Sec. 72, eastern part; on Sandy Creek 150 ft. above junction of small tributary almost on Adams-Franklin County line; 0.5 mile west of north-south road in western Franklin County

Collected: April 26, 1940

Elevation: 265 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.5	3.5	*Hattiesburg formation* Clay, dense, bright sky blue on fresh surface, but oxidized to yellow where exposed; contains numerous hard lumps; so-called "Fuller's earth"; Sample OC

Hicks Parker Property

Outcrop G502OC

Location: T.7 N., R.1 W., Sec. 35; left bank of St. Catherine Creek, a mile or more below its head

Dug: March 4, 1940

Elevation: 282 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	5.6	5.6	*Pascagoula formation* Clay, light-gray, sandy, mottled with red iron oxide splotches; much jointed; Sample OC

C. W. HAZLIP PROPERTY

OUTCROP G503OC

Location: T.7 N., R.2 W., Sec. 83, north central part; left bank of south fork of Kittering Creek, 360 ft. above mouth of a left tributary

Dug: May 11, 1940

Elevation: 252 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Pascagoula formation
1	3.0	3.0	1 full bag (large) dark gray sandy clay, mottled with red, from floor of creek and bank up to 2 feet above; Sample OC

WALLACE RATCLIFF PROPERTY

OUTCROP G504OC

Location: T.7 N., R.2 W., Sec. 62, southern part; left bank of left fork of Clear Creek about 900 ft. north of Mississippi Central Railroad

Dug: May 8, 1940

Elevation: 278 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Pascagoula? formation
1	3.0	3.0	Clay, golden yellow to lighter yellow, streaked with gray. Yellow ocher. 1 large bag; Sample OC

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ACKNOWLEDGMENTS

The geological and mineral resources survey of Adams County was made possible only through the co-operation of the county, which merits special acknowledgment. The Board of Supervisors as a body was ready at all times to place at the disposal of the geologist in charge whatever facilities he deemed necessary for the carrying on of the survey; the Natchez Association of Commerce helped with maps of the county and of the City of Natchez, as well as much other useful information; and individual citizens contributed in various ways to the work, notably through information concerning the locations of materials and places of geologic interest, and through maps and other data relating to former geologic work. Among the many citizens who furthered the work in one way or another, Mr. S. B. Laub, Mr. George Powlett, Mr. Walter P. Abbott, Mr. W. J. Byrne, Mr. George W. Armstrong, Mr. Leslie Kaiser, Mr. William Junkin and others of the St. Catherine Gravel Company, Mr. E. Blanchard, Dr. Chandler C. Emery, and Mr. C. Beltzhoover should be given special mention, as should also a number of others if space would permit.

The Work Projects Administration provided the workers for the prospecting and collection of samples, and the WPA officials individually furthered and encouraged the work.

Dr. W. C. Morse spent a few days with the field geologist, examining and photographing geologic features and checking interpretations. Also Dr. Richard R. Priddy and Mr. Frederic F. Mellen visited many points of geologic interest in Adams County and kindly gave the writer the benefit of their impressions. Dr. Louis C. Conant checked the base map of the county. The clerical staff of the State Survey is due much credit and the writer's gratitude for its faithful service in the preparation for the printer of the manuscript of the report on Adams County.

ADAMS COUNTY MINERAL RESOURCES

TESTS

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

INTRODUCTION

The clay resources of Adams County, as represented by 119 samples, are chiefly bond clays. One sample of loess (D67-1) and one sample of ochre (D504-OC) are included in the 119 samples tested.

The physical properties in the unburned state of the 117 samples of bond clays are so similar that the clays could not be classified into groups having particular sets of properties. However, on firing the clays to cone 03, 69 samples were so badly cracked that they were not fired to higher cone temperatures and were subsequently treated as a separate group of clays, hereafter referred to in this report as bond clays. The 49 samples, including the sample of loess, that did not crack on firing at cone 03 were treated as another group and fired to higher cone temperatures and are hereafter referred to as brick and tile clays.

Although the distinction between bond clays and brick and tile clays is based on the cracking of test pieces at cone 03, the cracking was not necessarily a result of firing as 33 of the 69 samples classified as bond clays cracked on drying, and it is likely that others were strained to such an extent on drying that they could not withstand firing. Most of the samples classified as brick and tile clays have bonding properties comparable to samples classified as bond clays, but since they did not crack on drying or firing, they are also suitable as the sole ingredient of many heavy clay products and are so classified. This designation is not intended to imply that the brick and tile clays are not suitable for use as bond clays.

During the routine testing of the samples it was evident from the accumulating data that most of the clays possessed unusual dry strength, a fact which would place them in the category of bond clays. To determine this possibility the unfired test pieces of the clays which had cracked on drying and firing were reground to pass a 20-mesh screen and mixed with 50 percent fire clay grog which had been prepared by crushing used fire brick to pass an 1/8 inch mesh screen. The mixture of clay and grog was made plastic with water and formed into 1x1x7-inch bars from which modulus of rupture and linear shrinkage values were determined in the unfired state and after burning to cone 10. The results of these tests are given in the table entitled, "Properties of bond clay and grog body mixtures."

The bond clays on which chemical analyses were made were studied as to their thixotropic or gelling properties. In this respect the clays were blunged with water, and with water and alkali (NaOH), in several proportions. Their viscosity, gel strength, pH, and specific gravity values were determined and are summarized in the tables entitled, "Thixotropic properties of bond clays." Further experimentation was conducted on two samples to determine their suitability for use as rotary drilling mud. This is shown in the table entitled, "Properties of drilling mud from bond clays."

BRICK AND TILE CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
G10	1	30.67	42.20	16.70	933	Dull gray
G11	1	17.62	18.74	6.71	562	Dull gray
G12	2	26.08	33.67	12.80	688	Reddish gray
G15	1	21.59	29.20	10.87	699	Neutral gray
G19	1	24.45	33.37	12.67	N. D.	Yellowish gray
G20	1	29.94	39.33	15.38	1095	Reddish gray
G27	OC	21.91	19.18	6.86	480	Reddish gray
G27	1	23.48	21.30	7.67	526	Reddish gray
G32	1	21.86	27.62	10.25	645	Dull gray
G33	1	24.20	36.60	14.09	809	Yellowish gray
G35	1	29.48	44.63	17.92	917	Greenish gray
G39	1	26.34	35.00	13.38	863	Reddish gray
G41	1	23.72	31.05	11.68	961	Yellowish gray
G42	1	29.98	41.25	16.27	1118	Neutral gray
G44	1	26.93	36.96	14.27	996	Dull gray
G45	2	31.17	44.30	17.72	971	Dull gray
G46	1	23.82	30.58	11.46	743	Yellowish gray
G57	1	25.27	28.45	10.58	992	Reddish gray
G62	1–2–3	32.00	44.93	18.07	993	Greenish gray
G63	1	29.78	35.97	13.84	689	Greenish gray
G67	1	19.31	3.17	1.08	N. D.	Brownish yellow
G69	1	26.14	28.05	10.41	454	Neutral gray
G71	1	33.20	38.52	15.01	830	Neutral gray
G72	1	31.70	44.17	17.67	761	Greenish gray
G73	2	27.39	40.77	16.03	849	Neutral gray
G78	1	31.67	43.10	17.14	976	Neutral gray
G80	1	32.20	46.52	18.87	340	Neutral gray
G82	2	25.41	40.17	15.75	1206	Dull gray
G83	1	30.45	41.70	16.46	913	Neutral gray
G87	1	22.52	19.64	7.05	419	Reddish gray
G88	1	28.01	42.02	16.65	711	Yellowish gray
G89	1	20.88	26.55	9.79	932	Greenish gray
G90	1	33.99	46.42	18.82	991	Greenish gray
G91	2	32.92	46.38	18.77	923	Neutral gray
G91	3	32.12	43.18	17.18	705	Greenish gray
G92	1–2–3	29.10	38.13	14.82	759	Reddish gray
G93	1	30.11	33.38	12.67	538	Neutral gray
G94	1	29.70	41.13	16.22	848	Greenish gray
G94	2	29.41	40.42	15.89	954	Greenish gray
G95	1	26.14	33.02	12.54	807	Greenish gray
G96	1	36.25	48.47	19.84	1569	Yellowish gray
G99	1	27.91	37.69	14.59	835	Reddish gray
G103	1	24.23	32.78	12.41	638	Reddish brown
G104	1	26.30	34.52	13.20	849	Reddish gray
G111	1	27.87	38.93	15.19	882	Yellowish gray
G114	1	26.11	40.37	15.84	1120	Greenish gray
G119	1	22.37	28.12	10.45	851	Greenish gray
G502	OC	24.80	28.35	10.54	717	Neutral gray
G503	OC	25.40	29.67	11.08	588	Reddish gray

SCREEN ANALYSES
(Ground to pass 20-mesh screen)

Sample G11-1

Retained on screen	Percent	Character of residue
60	1.10	Abundance of calcareous nodules; considerable quantity of nodules of cemented opaque silt grains.
100	1.13	Abundance of calcareous nodules; considerable quantity of nodules of cemented opaque silt grains; small amount of quartz.
250	8.07	Abundance of quartz; small amount of calcareous nodules and nodules of cemented opaque silt grains.
Cloth	89.70	Clay substance including residue from above.

Sample G35-1

Retained on screen	Percent	Character of residue
60	6.51	Abundance of quartz; considerable quantity of nodules of cemented silt grains; considerable quantity stained with limonite.
100	6.37	Abundance of limonitic nodules of cemented silt grains, some not stained; considerable quantity of quartz.
250	5.81	Abundance of limonitic nodules of cemented silt grains; considerable quantity of quartz.
Cloth	81.31	Clay substance including residue from above.

Sample G42-1

Retained on screen	Percent	Character of residue
60	8.71	Abundance of gray arenaceous clay nodules, some limonitic stained.
100	9.36	Abundance of gray arenaceous clay nodules, some limonitic stained.
250	10.14	Abundance of gray arenaceous clay nodules, some limonitic stained.
Cloth	70.79	Clay substance including residue from above.

SAMPLE G78-1

Retained on screen	Percent	Character of residue
60	8.51	Abundance of arenaceous gray clay nodules; small amounts of earthy hematite and calcareous material.
100	4.84	Abundance of arenaceous gray clay nodules; small amount of earthy hematite; trace of calcareous material.
250	5.40	Abundance of gray clay nodules; small amounts of hematite and quartz.
Cloth	81.25	Clay substance·including residue from above.

SAMPLE G83-1

Retained on screen	Percent	Character of residue
60	6.27	Abundance of nodules of cemented opaque silt grains; considerable quantity of hematite.
100	9.22	Abundance of nodules of cemented opaque silt grains; small amounts of hematite and quartz.
250	17.65	Abundance of nodules of cemented opaque silt grains; considerable quantity of quartz; small amount of hematite.
Cloth	66.86	Clay substance including residue from above.

Alta Ray Gault, technician.

CHEMICAL ANALYSES*

SAMPLE G11-1

Ignition loss 4.57	Iron oxide, Fe_2O_3 ... 2.12	Magnesia, MgO 0.46
Silica, SiO_2 ....78.52	Titania, TiO_2 .... 0.80	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ......11.81	Lime, CaO 1.38	Alkalies, (K_2O, Na_2O) ....Trace

Soluble Silica in 10 percent Na_2CO_3 solution .... 10.52 percent

SAMPLE G35-1

Ignition loss 6.86	Iron oxide, Fe_2O_3 ... 4.22	Magnesia, MgO 0.76
Silica, SiO_2 .... 69.97	Titania, TiO_2 .... 0.78	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ...... 15.39	Lime, CaO 1.29	Alkalies, (K_2O, Na_2O) 0.20

Soluble Silica in 10 percent Na_2CO_3 solution .... 9.82 percent

SAMPLE G42-1

Ignition loss 6.87	Iron oxide, Fe_2O_3 ... 4.06	Magnesia, MgO 0.50
Silica, SiO_2 ....65.91	Titania, TiO_2 .... 0.42	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ..... 20.22	Lime, CaO 2.07	Alkalies, (K_2O, Na_2O) 0.16

Soluble Silica in 10 percent Na_2CO_3 solution .... 5.94 percent

SAMPLE G78-1

Ignition loss 5.98	Iron oxide, Fe_2O_3 ... 5.14	Magnesia, MgO 0.58
Silica, SiO_2 ....67.93	Titania, TiO_2 .... 1.15	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ..... 16.90	Lime, CaO 0.67	Alkalies, (K_2O, Na_2O) 0.54

Soluble Silica in 10 percent Na_2CO_3 solution .... 8.56 percent

SAMPLE G83-1

Ignition loss 5.49	Iron oxide, Fe_2O_3 ... 4.38	Magnesia, MgO 1.08
Silica, SiO_2 ....71.71	Titania, TiO_2 .... 0.93	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ......15.95	Lime, CaO 0.66	Alkalies, (K_2O, Na_2O) 0.07

Soluble Silica in 10 percent Na_2CO_3 solution .... 7.63 percent

* Analyses of residue washed through 250 mesh screen.

B. F. Mandlebaum, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes G10, G11, G12, G15, G16

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	Color and remarks	
G10 1	03	23.80	12.49	1.90	2.50	1.49	.50	Salmon	St. H.
	1	21.23	10.90	1.94	2.47	3.41	1.18	Lt. red	
	3	21.47	11.06	1.94	2.47	3.42	1.18	Lt. red	
	5	21.19	10.85	1.95	2.47	3.88	1.32	Lt. red	
	7	20.93	10.70	1.97	2.47	4.03	1.39	Lt. red	
	9	20.51	10.37	1.98	2.49	5.06	1.73	Red	
	11	19.48	9.69	2.01	2.49	6.42	2.22	Red	
	13	19.20	9.64	1.99	2.48	6.11	2.11	Lt. brown	
	14	9.58	4.87	1.97	2.18	4.74	1.63	Dk. brown	
G11 1	03	24.53	12.76	1.92	2.54	-2.15	-.74	Buff	St. H.
	1	24.91	12.85	1.94	2.58	-1.21	-.44	Buff	
	3	23.51	12.17	1.93	2.53	-1.07	-.37	Buff	
	5	23.45	12.11	1.94	2.53	-.93	-.33	Buff	
	7	22.42	11.60	1.95	2.52	-.67	-.24	Buff	
	9	23.33	11.96	1.95	2.53	-.54	-.20	Buff	
	11	22.89	11.81	1.94	2.51	-.40	-.13	Buff	
	13	22.16	11.52	1.92	2.47	-2.26	-.77	Dk. buff	
	14	23.44	12.60	1.86	2.42	-5.44	-1.87	Brown	
G12 2	03	27.22	14.29	1.91	2.62	.61	.24	Lt. red	St. H.
	1	26.51	13.79	1.92	2.62	1.51	.54	Lt. red	
	3	25.82	13.38	1.93	2.60	1.81	.64	Lt. red	
	5	25.34	13.14	1.93	2.59	1.95	.67	Lt. red	
	7	24.88	12.81	1.95	2.59	2.25	.77	Lt. red	
	9	24.77	12.64	1.96	2.60	3.32	1.15	Red	
	11	23.78	12.18	1.95	2.56	3.27	1.11	Brownish red	
	13	22.94	12.04	1.91	2.48	1.03	.37	Brown	
G15 1	03	21.72	10.92	1.99	2.54	4.67	1.59	Salmon	St. H.
	1	18.76	9.21	2.03	2.50	6.60	2.25	Lt. red	
	3	18.63	9.23	2.02	2.49	5.99	2.04	Lt. red	
	5	17.94	8.80	2.04	2.48	6.84	2.36	Lt. red	
	7	17.40	8.52	2.04	2.47	6.93	2.39	Lt. red	
	9	17.11	8.39	2.04	2.46	6.99	2.39	Lt. red	
	11	17.51	8.62	2.03	2.47	6.79	2.32	Buff	
	13	17.36	8.55	2.03	2.46	6.50	2.22	Buff	
	14	21.06	10.83	1.95	2.47	2.94	1.01	Brown	
G16 1	03	23.55	11.82	1.96	2.57	-.44	-.17	Salmon	St. H.
	1	21.08	10.53	2.00	2.53	1.62	.57	Lt. red	
	3	18.89	9.42	2.00	2.47	1.92	.67	Lt. red	
	5	19.62	9.84	2.00	2.48	1.76	.60	Lt. red	
	7	18.68	9.33	2.00	2.46	2.20	.74	Red	
	9	17.71	8.76	2.02	2.45	2.64	.91	Red	
	11	16.39	8.07	2.03	2.43	3.25	1.11	Lt. brown	
	13	15.98	7.91	2.02	2.40	2.61	.91	Lt. brown	
	14	10.44	5.45	1.91	2.14	-2.87	-.98	Dk. brown	Bl.

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

TEST HOLES G20, G27, G32, G33

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	Color and remarks	
G20 1	03	21.47	11.07	1.94	2.47	4.15	1.42	Salmon	St. H.
	1	19.15	9.66	1.98	2.46	6.02	2.08	Salmon	
	3	17.59	8.82	1.99	2.42	6.81	2.36	Lt. red	
	5	17.02	8.46	2.01	2.42	7.47	2.57	Lt. red	
	7	16.49	8.01	2.02	2.41	7.71	2.77	Red	
	9	16.51	8.06	2.05	2.45	9.43	3.27	Red	
	11	16.59	8.02	2.07	2.48	10.36	3.59	Lt. brown	
	13	17.71	8.61	2.05	2.50	9.71	3.38	Brown	
G27 OC	03	27.48	14.27	1.95	2.72	6.01	2.08	Buff	St. H.
	1	26.51	13.47	1.97	2.68	9.80	3.42	Salmon	
	3	26.03	13.18	1.98	2.68	10.20	3.52	Salmon	
	5	24.91	12.52	1.99	2.65	10.83	3.77	Salmon	
	7	23.91	11.89	2.01	2.65	11.93	4.18	Salmon	
	9	22.57	11.09	2.04	2.64	12.85	4.50	Salmon	
	11	21.52	10.65	2.03	2.59	12.56	4.39	Buff	
	13	21.04	10.35	2.03	2.57	12.22	4.28	Buff	
	14	23.15	12.03	1.93	2.51	7.65	2.64	Brown	
G27 1	03	29.63	15.59	1.90	2.70	7.56	2.60	Salmon	St. H.
	1	28.47	14.79	1.93	2.69	8.87	3.06	Salmon	
	3	26.10	13.31	1.96	2.66	10.79	3.74	Salmon	
	5	25.16	12.72	1.98	2.64	11.40	3.95	Salmon	
	7	23.93	11.97	2.00	2.63	12.32	4.32	Salmon	
	9	23.45	11.61	2.02	2.64	13.03	4.57	Salmon	
	11	22.49	11.17	2.01	2.60	13.24	4.65	Buff	
	13	22.13	11.03	2.01	2.58	12.69	4.43	Buff	
	14	23.67	12.78	1.90	2.49	7.52	2.60	Brown	
G32 1	03	26.06	13.45	1.94	2.62	1.18	.40	Buff	St. H.
	1	22.66	11.43	1.99	2.58	3.67	1.25	Salmon	
	3	21.29	10.67	1.99	2.53	3.86	1.32	Salmon	
	5	20.95	10.50	1.99	2.53	3.85	1.32	Salmon	
	7	20.11	10.09	1.99	2.50	4.02	1.39	Salmon	
	9	19.89	9.91	2.00	2.50	4.60	1.56	Salmon	
	11	18.80	9.39	2.00	2.47	3.97	1.35	Buff	
	13	18.86	9.50	1.99	2.45	3.41	1.18	Buff	
	14	22.87	11.86	1.93	2.50	.59	.20	Brown	
G33 1	03	21.89	11.27	1.94	2.49	.90	.30	Salmon	St. H.
	1	18.94	9.53	1.99	2.46	2.32	.81	Lt. red	
	3	19.65	9.93	1.98	2.46	2.70	.91	Lt. red	
	5	19.52	9.89	1.98	2.45	2.42	.84	Lt. red	
	7	18.69	9.45	1.98	2.43	2.63	.91	Red	
	9	18.71	9.39	1.99	2.45	3.31	1.15	Red	
	11	15.72	7.86	2.00	2.37	3.10	1.04	Brown, specked	
	13	13.77	6.98	1.97	2.29	2.46	.84	Brown, specked	
	14	19.00	11.01	1.72	2.13	-11.88	-4.14	Dk. brown, specked	Bl.

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

TEST HOLES G35, G39, G41, G42, G44

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	Color and remarks	
G35 1	03	15.44	6.99	2.09	2.42	11.66	4.06	Lt. red	St. H.
	1	13.77	6.57	2.21	2.61	14.01	4.94	Red	
	3	13.81	6.29	2.22	2.48	14.03	4.94	Red	
	5	10.54	4.75	2.22	2.48	14.12	4.98	Red	
	7	10.23	4.60	2.19	2.55	15.16	5.35	Dk. red	
	9	8.91	3.99	2.24	2.45	14.36	5.05	Dk. red	
	11	16.71	8.64	1.94	2.33	2.18	.74	Brown	Bl.
	13	21.96	12.52	1.76	2.26	-6.72	-2.32	Brown	Bl.
G39 1	03	24.27	12.86	1.89	2.49	1.42	.50	Salmon	St. H.
	1	22.07	11.48	1.92	2.47	3.20	1.08	Lt. red	
	3	21.05	10.91	1.94	2.46	4.09	1.39	Lt. red	
	5	20.68	10.62	1.95	2.46	4.35	1.49	Lt. red	
	7	20.64	10.48	1.96	2.46	4.64	1.59	Lt. red	
	9	20.23	10.24	1.97	2.48	5.90	2.01	Red	
	11	18.87	9.52	1.99	2.45	5.78	1.97	Lt. brown	
	13	18.01	9.17	1.96	2.39	5.42	1.87	Brown	
	14	9.27	5.04	1.83	2.02	-2.36	-.81	Dk. brown	Bl.
G41 1	03	22.92	11.73	1.95	2.53	.27	.10	Salmon	St. H.
	1	20.83	10.60	1.97	2.51	1.67	.53	Lt. red	
	3	20.17	10.17	1.98	2.48	1.85	.64	Lt. red	
	5	20.94	10.58	1.98	2.50	2.11	.74	Lt. red	
	7	20.15	10.14	1.99	2.49	2.38	.89	Lt. red	
	9	20.10	10.01	2.01	2.52	2.93	1.01	Red	
	11	18.53	9.18	2.02	2.48	3.92	1.35	Lt. brown	
	13	17.92	8.81	2.03	2.47	4.33	1.49	Brown	
	14	8.96	4.50	1.99	2.19	3.39	1.15	Brown	Bl.
G42 1	03	21.70	11.20	1.94	2.48	5.02	1.73	Salmon	St. H.
	1	22.68	11.25	2.01	2.62	8.73	3.02	Salmon	
	3	14.77	7.28	2.03	2.38	9.68	3.34	Lt. red	
	5	15.09	7.42	2.03	2.39	9.47	3.27	Lt. red	
	7	14.24	6.74	2.06	2.39	10.57	3.67	Lt. red	
	9	13.60	6.46	2.10	2.44	12.59	4.39	Red	
	11	11.79	5.52	2.14	2.42	13.95	4.90	Lt. brown	
	13	10.96	5.16	2.11	2.37	12.90	4.50	Brown	
	14	22.03	12.95	1.71	2.18	-7.82	-2.71	Dk. brown	Bl.
G44 1	03	24.44	12.00	1.96	2.48	3.08	1.04	Salmon	St. H.
	1	21.04	11.08	2.01	2.65	5.28	1.80	Lt. red	
	3	15.59	7.71	2.02	2.39	5.46	1.87	Lt. red	
	5	14.60	7.20	2.03	2.38	5.88	2.01	Lt. red	
	7	14.52	7.13	2.04	2.38	6.49	2.22	Lt. red	
	9	13.35	6.47	2.06	2.38	7.56	2.60	Red	
	11	14.56	7.01	2.08	2.43	7.94	2.74	Lt. brown	
	13	14.83	7.26	2.04	2.40	6.38	2.18	Brown	
	14	14.44	7.01	1.97	2.30	3.43	1.18	Dk. brown	

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

TEST HOLES G45, G46, G57, G62, G63, G67

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	Color and remarks
G45 2	03	17.85	8.82	2.02	2.46	8.19	2.81	Salmon St. H.
	1	12.66	5.97	2.13	2.42	12.59	4.39	Salmon
	3	9.84	4.55	2.17	2.40	14.55	5.12	Lt. red
	5	9.94	4.61	2.16	2.40	14.10	4.94	Lt. red
	7	8.70	3.98	2.18	2.38	14.74	5.20	Red
	9	6.96	3.12	2.23	2.39	16.73	5.95	Brownish red
	11	7.50	3.46	2.16	2.33	14.23	5.01	Brown
G46 1	03	17.77	8.39	2.12	2.57	10.69	3.70	Salmon St. H.
	1	14.76	5.20	2.20	2.48	14.07	4.94	Lt. red
	3	9.42	4.26	2.21	2.44	14.93	5.27	Lt. red
	5	10.94	4.95	2.21	2.48	14.51	5.12	Lt. red
	7	8.90	4.00	2.22	2.44	14.92	5.27	Lt. red
	9	8.19	3.66	2.24	2.44	15.71	5.57	Red
	11	7.14	3.17	2.25	2.43	15.84	5.61	Brown
	13	7.29	3.28	2.22	2.40	15.15	5.35	Brown
G57 1	03	27.33	14.63	1.87	2.57	.96	.33	Salmon
	1	27.20	14.29	1.89	2.59	1.23	.44	Lt. red
	3	26.07	13.75	1.89	2.56	1.93	.67	Lt. red
	5	26.34	13.81	1.91	2.59	2.69	.91	Lt. red
	7	25.55	13.47	1.90	2.56	2.54	.87	Red
	9	23.39	12.22	1.91	2.50	3.30	1.32	Red
	11	24.07	12.38	1.95	2.56	4.64	1.59	Brown
	13	23.65	12.20	1.94	2.54	4.08	1.39	Brown
	14	9.59	5.08	1.89	2.19	2.23	.77	Dk. brown
G62 1-2-3	03	17.43	8.49	2.05	2.49	9.50	3.27	Salmon St. H.
	1	14.91	7.07	2.10	2.48	11.91	4.17	Red
	3	13.30	6.27	2.12	2.45	12.58	4.39	Red
	5	13.53	6.40	2.11	2.44	12.33	4.32	Red
	7	13.49	6.31	2.14	2.47	13.22	4.65	Red
	9	11.82	5.46	2.16	2.45	13.37	4.68	Dk. red
	11	12.37	5.83	2.12	2.41	12.65	4.43	Brown
G63 1	03	24.40	12.74	1.92	2.53	5.47	1.87	Lt. red
	1	23.60	12.11	1.95	2.55	7.02	2.42	Lt. red
	3	22.14	11.23	1.97	2.54	7.84	2.71	Lt. red St. H.
	5	22.24	11.26	1.97	2.54	8.30	2.85	Lt. red
	7	20.55	10.33	1.99	2.51	8.76	3.02	Red
	9	20.42	10.14	2.00	2.53	10.64	3.70	Red
	11	15.07	7.05	2.08	2.48	14.53	5.12	Brown
G67 1	03	36.62	21.69	1.69	2.65	1.36	.47	Brownish red
	1	31.73	17.68	1.80	2.63	7.27	.50	Brownish red
	3	28.13	15.40	1.89	2.63	10.10	3.49	Brownish red St. H.
	5	21.18	10.61	2.03	2.59	17.95	6.40	Reddish brown
	7	6.31	2.81	2.23	2.48	25.34	9.31	Brown
	9	.13	.06	2.12	2.12	20.83	7.52	Reddish brown, glazed

Abbreviations: St. H., steel hard.

TEST HOLES G69, G71, G72, G73, G78

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	Color and remarks	
G69 1	03	26.74	14.28	1.87	2.56	5.43	1.87	Buff	St. H.
	1	23.41	11.95	1.96	2.55	9.17	3.17	Buff	
	3	22.37	11.25	1.98	2.31	10.49	3.63	Buff	
	5	21.61	10.90	1.98	2.53	10.67	3.70	Buff	
	7	20.38	10.26	1.99	2.49	10.83	3.77	Buff	
	9	20.65	10.25	1.99	2.52	11.14	3.88	Buff	
	11	19.66	9.82	1.99	2.47	10.92	3.81	Buff	
	13	19.66	9.88	1.99	2.48	11.04	3.85	Buff	
	14	23.60	12.44	1.90	2.48	7.20	2.46	Brown	
G71 1	03	28.61	15.69	1.83	2.56	6.21	2.15	Salmon	St. H.
	1	25.09	13.23	1.90	2.53	10.21	3.56	Salmon	
	3	23.08	12.03	1.92	2.49	11.14	3.88	Salmon	
	5	22.24	11.57	1.93	2.48	11.25	3.92	Salmon	
	7	22.12	11.42	1.93	2.40	12.08	4.21	Salmon	
	9	18.66	9.48	2.00	2.38	12.71	4.46	Salmon	
	11	18.31	9.29	1.97	2.40	13.27	4.65	Reddish buff	
	13	18.71	9.49	1.97	2.43	13.47	4.72	Buff	
	14	20.76	10.81	1.92	2.42	11.24	3.92	Dk. buff	
G72 1	03	19.91	9.92	2.00	2.50	4.96	1.70	Salmon	St. H.
	1	18.24	9.03	2.02	2.48	5.76	1.97	Salmon	
	5	16.46	8.11	2.03	2.43	5.96	2.04	Lt. red	
	7	16.98	8.36	2.03	2.45	6.40	2.18	Red	
	9	15.40	7.51	2.05	2.43	7.14	2.46	Red	
	11	15.15	7.37	2.06	2.42	7.80	2.67	Dk. red	
	13	15.37	7.51	2.05	2.41	6.51	2.22	Brown	
	14	11.15	5.69	1.96	2.20	3.32	1.15	Dk. brown	
G73 2	03	19.72	9.92	1.99	2.48	4.99	1.70	Salmon	
	1	16.66	8.17	2.04	2.43	6.94	2.39	Lt. red	St. H.
	3	15.97	7.80	2.05	2.43	8.10	2.78	Lt. red	
	5	16.13	7.92	2.04	2.43	7.67	2.64	Lt. red	
	7	15.90	7.73	2.06	2.44	8.19	2.81	Lt. red	
	9	15.06	7.24	2.08	2.43	9.49	3.27	Red	
	11	15.33	7.32	2.09	2.47	10.00	3.45	Dk. red	
	13	16.39	7.96	2.06	2.46	9.22	3.20	Brown	
	14	17.13	9.23	1.86	2.25	−1.90	−.64	Dk. brown	
G78 1	03	20.11	10.19	1.97	2.47	9.21	3.20	Salmon	St. H.
	1	17.51	8.83	1.98	2.40	10.22	3.56	Salmon	
	3	15.77	7.88	2.00	2.37	10.93	3.81	Lt. red	
	5	13.89	6.89	2.02	2.34	11.09	3.85	Lt. red	
	7	13.11	6.50	2.02	2.32	11.74	4.10	Lt. red	
	9	12.46	6.08	2.05	2.34	12.72	4.46	Red	
	11	12.36	5.98	2.06	2.35	13.74	4.83	Brown	
	13	10.91	5.45	2.07	2.32	13.07	4.57	Brown	
	14	13.14	6.64	1.98	2.28	9.78	3.38	Dk. brown	

Abbreviation: St. H., steel hard.

TEST HOLES G80, G82, G83, G87, G88

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	Color and remarks	
G80 1	03	17.53	8.62	2.03	2.47	9.31	3.24	Salmon	St. H.
	1	15.65	7.49	2.08	2.46	10.71	3.74	Lt. red	
	3	12.39	6.08	2.09	2.39	12.09	4.21	Lt. red	
	5	12.48	5.87	2.12	2.43	13.05	4.57	Lt. red	
	7	11.84	5.49	2.16	2.45	13.85	4.87	Red	
	9	11.99	5.52	2.17	2.47	15.10	5.31	Red	
	11	10.18	4.75	2.16	2.39	13.95	4.90	Brown	
	13	10.04	4.63	2.16	2.40	14.97	5.27	Dk. brown	
G82 2	03	20.04	10.16	1.97	2.47	2.85	.98	Salmon	St. H.
	1	19.04	9.63	1.98	2.44	2.90	.98	Lt. red	
	3	16.93	8.55	1.98	2.39	3.05	1.04	Lt. red	
	5	17.19	8.67	1.98	2.39	3.26	1.11	Lt. red	
	7	17.46	8.84	1.98	2.39	3.16	1.08	Lt red	
	9	17.28	8.72	1.99	2.40	2.97	1.01	Red	
	11	17.03	8.63	1.97	2.38	2.66	.91	Buff	
	13	19.61	9.99	1.97	2.43	2.15	.74	Dk. brown	
	14	21.46	11.29	1.90	2.42	-1.01	-.37	Brown	
G83 1	03	25.13	12.98	1.92	2.56	3.16	1.08	Salmon	
	1	23.57	12.10	1.94	2.54	4.20	1.42	Salmon	St. H.
	3	22.49	11.57	1.94	2.51	4.93	1.70	Lt. red	
	5	21.06	10.75	1.96	2.49	5.75	1.97	Lt. red	
	7	20.54	10.39	1.98	2.49	6.05	2.08	Red	
	9	19.61	9.84	1.99	2.47	6.74	2.32	Red	
	11	19.14	9.57	2.00	2.48	7.26	2.50	Brown	
	13	19.14	9.53	2.00	2.48	7.31	2.53	Brown	
	14	16.86	8.75	1.92	2.32	3.88	1.32	Dk. brown	
G87 1	03	29.61	15.68	1.89	2.68	6.17	2.11	Buff	St. H.
	1	27.74	14.62	1.94	2.68	8.66	2.99	Buff	
	3	26.64	13.62	1.96	2.67	9.52	3.31	Buff	
	5	25.76	13.10	1.97	2.65	9.77	3.38	Buff	
	7	25.24	13.09	1.98	2.65	10.29	3.56	Buff	
	9	24.20	12.14	1.99	2.63	10.92	3.81	Buff	
	11	22.68	11.39	1.99	2.58	11.32	3.95	Buff	
	13	24.25	12.60	1.92	2.54	7.71	2.67	Brown	
	14	22.62	11.79	1.92	2.48	6.97	2.39	Brown	
G88 1	03	22.39	11.12	2.01	2.60	4.35	1.49	Lt. red	St. H.
	1	20.61	10.12	2.04	2.56	5.74	1.97	Lt. red	
	3	20.01	9.86	2.04	2.54	5.31	1.83	Lt. red	
	5	19.60	9.60	2.04	2.53	5.58	1.90	Red	
	7	18.85	9.16	2.06	2.54	6.64	2.29	Red	
	9	18.96	9.20	2.06	2.54	6.79	2.32	Red	
	11	16.05	7.68	2.09	2.49	7.66	2.64	Brown	
	13	16.36	7.90	2.07	2.47	6.86	2.36	Brown	
	14	13.44	7.01	1.92	2.22	-.96	-.33	Dk. brown	

Abbreviation: St. H., steel hard.

TEST HOLES G89, G90, G91, G92

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	Color and remarks	
G89 1	03	22.93	11.88	1.93	2.50	-.57	-.20	Salmon	St. H.
	1	21.96	11.30	1.95	2.49	.44	.17	Salmon	
	3	20.06	10.22	1.96	2.45	.86	.30	Salmon	
	5	20.19	10.28	1.97	2.46	1.31	.47	Salmon	
	7	19.03	9.64	1.98	2.45	.87	.30	Salmon	
	9	19.73	10.02	1.97	2.45	1.30	.44	Salmon	
	11	19.54	9.62	1.96	2.44	1.02	.37	Buff	
	13	19.62	10.05	1.95	2.43	.44	.17	Buff	
	14	21.81	11.51	1.89	2.38	-3.08	-1.04	Brown	
G90 1	03	21.75	11.22	1.93	2.47	7.18	2.46	Salmon	St. H.
	1	18.19	9.19	1.98	2.42	9.37	3.24	Lt. red	
	3	15.40	7.71	2.00	2.37	9.98	3.45	Lt. red	
	5	14.71	7.26	2.03	2.37	11.02	3.85	Red	
	7	14.58	7.15	2.04	2.39	11.97	4.17	Red	
	9	14.42	6.75	2.08	2.43	13.90	4.87	Red	
	11	13.27	6.25	2.13	2.44	15.26	5.38	Brown	
	13	11.68	5.53	2.11	2.39	14.87	5.24	Brown	
	14	23.32	13.46	1.73	2.26	-3.61	-1.25	Dk. brown	Bl.
G91 2	03	18.25	9.10	2.00	2.46	8.67	2.99	Salmon	St. H.
	1	13.99	6.83	2.04	2.37	10.65	3.70	Lt. red	
	3	11.71	5.65	2.07	2.35	11.71	4.10	Lt. red	
	5	12.68	6.07	2.08	2.35	12.36	4.32	Lt. red	
	7	12.61	6.02	2.09	2.39	12.90	4.50	Red	
	9	12.62	5.96	2.11	2.43	13.56	4.76	Red	
	11	10.94	5.11	2.14	2.40	15.12	5.35	Brown	
	13	10.96	5.12	2.14	2.39	13.91	4.90	Brown	
	14	18.99	10.16	1.87	2.32	2.18	.74	Dk. brown	
G91 3	03	21.36	11.02	1.94	2.47	5.82	2.01	Salmon	St. H.
	1	21.02	10.54	1.99	2.46	8.51	2.95	Lt. red	
	3	15.57	7.67	2.03	2.40	10.55	3.67	Lt. red	
	5	16.31	8.11	2.01	2.40	9.79	3.38	Lt. red	
	7	15.08	7.33	2.06	2.42	11.13	3.88	Red	
	9	15.02	7.26	2.07	2.44	11.97	4.17	Red	
	11	13.35	6.24	2.14	2.47	14.67	5.16	Brown	
	13	11.61	5.44	2.14	2.42	14.86	5.24	Brown	
	14	19.67	10.94	1.81	2.26	-.76	-.27	Dk. brown	Bl.
G92 1-2-3	03	25.96	13.37	1.89	2.56	2.22	.77	Salmon	
	1	24.12	12.24	1.92	2.53	4.34	1.49	Lt. red	St. H.
	3	23.58	12.17	1.94	2.54	4.80	1.66	Lt. red	
	5	22.80	11.72	1.94	2.52	5.07	1.73	Red	
	7	22.18	11.23	1.97	2.54	6.20	2.11	Red	
	9	22.20	11.33	1.97	2.54	6.29	2.15	Red	
	11	21.58	10.79	2.00	2.55	7.62	2.64	Dk. red	
	13	21.32	10.72	1.99	2.53	7.13	2.46	Dk. red	
	14	12.42	6.44	1.93	2.20	4.29	1.46	Brown	

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

TEST HOLES G93, G94, G95, G96

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	Color and remarks	
G93 1	03	27.47	15.19	1.85	2.58	3.49	1.18	Salmon	
	1	26.36	13.96	1.89	2.56	5.06	1.73	Lt. red	St. H.
	3	25.85	13.67	1.90	2.55	5.46	1.87	Lt. red	
	5	25.15	13.15	1.91	2.55	6.46	2.22	Lt. red	
	7	24.28	12.57	1.93	2.55	7.66	2.64	Red	
	9	22.86	11.67	1.96	2.54	8.80	3.02	Red	
	11	20.96	10.51	1.99	2.53	10.44	3.63	Lt. brown	
	13	21.23	10.64	2.00	2.53	10.71	3.74	Lt. brown	
	14	11.29	5.71	1.97	2.23	9.88	3.42	Dk. brown	
G94 1	03	23.99	12.38	1.93	2.54	5.29	1.80	Buff	St. H.
	1	17.75	8.83	2.01	2.45	8.34	2.88	Buff	
	3	14.73	7.25	2.03	2.38	9.57	3.31	Buff	
	5	14.21	6.92	2.06	2.39	10.84	3.77	Lt. red	
	7	13.84	6.74	2.06	2.38	10.90	3.77	Lt. red	
	9	14.14	6.73	2.09	2.43	12.06	4.21	Red	
	11	13.02	6.31	2.12	2.44	12.98	4.54	Lt. brown	
	13	14.17	6.74	2.10	2.45	12.58	4.39	Lt. brown	
	14	13.08	6.42	2.04	2.34	9.68	3.34	Dk. brown	
G94 2	03	25.77	13.34	1.93	2.60	3.80	1.28	Buff	St. H.
	1	21.74	11.08	1.96	2.51	5.52	1.90	Buff	
	3	19.10	9.61	1.98	2.46	7.57	2.60	Buff	
	5	17.16	8.54	2.01	2.42	7.99	2.74	Lt. red	
	7	16.83	8.37	2.02	2.41	8.14	2.81	Lt. red	
	9	16.39	8.03	2.04	2.43	9.15	3.17	Red	
	11	16.18	7.80	2.08	2.48	10.50	3.63	Lt. brown	
	13	16.46	7.97	2.07	2.47	10.26	3.56	Lt. brown	
	14	14.09	7.02	2.01	2.33	7.77	2.67	Dk. brown	
G95 1	03	25.09	13.00	1.93	2.60	1.84	.64	Salmon	
	1	25.00	12.82	1.95	2.60	2.91	1.01	Salmon	
	3	23.59	12.04	1.96	2.57	3.22	1.11	Lt. red	St. H.
	5	23.28	11.87	1.96	2.55	3.71	1.28	Lt. red	
	7	22.92	11.66	1.96	2.55	3.94	1.35	Lt. red	
	9	22.19	11.20	1.98	2.55	4.18	1.42	Red	
	11	21.82	10.96	1.99	2.53	5.27	1.80	Red	
	13	20.72	10.40	1.99	2.51	5.50	1.87	Brown	
	14	10.38	5.28	1.96	2.16	3.83	1.32	Dk. brown	
G96 1	03	25.81	13.73	1.88	2.54	4.59	1.56	Salmon	St. H.
	1	24.41	12.74	1.91	2.54	6.03	2.08	Lt. red	
	3	23.49	12.12	1.94	2.53	6.52	2.25	Lt. red	
	5	22.54	11.70	1.93	2.48	6.77	2.32	Red	
	7	22.82	11.82	1.93	2.50	6.56	2.25	Red	
	9	21.35	11.03	1.98	2.41	7.62	2.64	Red	
	11	18.90	9.46	1.99	2.46	10.29	3.56	Lt. brown	
	13	12.25	6.14	1.99	2.28	9.74	3.38	Dk. brown	

Abbreviation: St. H., steel hard.

TEST HOLES G99, G103, G104, G111, G114

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	Color and remarks	
G99 1	03	21.26	10.38	2.05	2.60	9.94	3.45	Salmon	St. H.
	1	18.88	9.04	2.09	2.57	11.69	4.06	Lt. red	
	3	16.53	7.97	2.10	2.51	12.44	4.35	Lt. red	
	5	16.13	7.65	2.11	2.50	12.46	4.35	Lt. red	
	7	14.45	7.00	2.12	2.48	12.93	4.54	Lt. red	
	9	15.10	7.14	2.11	2.48	13.06	4.57	Red	
	11	13.17	6.00	2.13	2.47	13.69	4.79	Lt. brown	
	13	14.66	7.06	2.08	2.44	11.44	3.99	Brown	
	14	13.00	6.36	2.04	2.35	10.07	3.49	Dk. brown	
G103 1	03	24.32	12.32	1.97	2.60	2.44	.84	Salmon	
	1	21.06	10.35	2.03	2.58	5.25	1.80	Lt. red	St. H.
	3	19.02	9.38	2.03	2.51	5.45	1.83	Lt. red	
	5	19.00	9.25	2.04	2.51	5.68	1.94	Lt. red	
	7	18.49	9.07	2.04	2.50	5.76	1.97	Lt. red	
	9	18.10	8.88	2.04	2.48	5.80	1.97	Red	
	11	17.95	8.84	2.03	2.47	5.16	1.76	Reddish brown	
	13	17.61	8.79	2.01	2.43	4.17	1.42	Lt. brown	
	14	19.09	9.81	1.95	2.40	1.34	.47	Dk. brown	
G104 1	03	22.92	11.67	1.97	2.57	3.56	1.21	Salmon	
	1	22.56	11.35	1.98	2.56	4.12	1.42	Salmon	St. H.
	3	21.12	10.63	1.99	2.52	4.81	1.66	Lt. red	
	5	20.86	10.44	1.99	2.52	5.07	1.73	Lt. red	
	7	20.94	10.47	2.00	2.52	5.51	1.90	Lt. red	
	9	19.69	9.78	2.02	2.51	6.01	2.08	Red	
	11	19.17	9.48	2.02	2.50	6.53	2.25	Reddish brown	
	13	18.72	9.42	1.99	2.44	4.83	1.66	Brown	
	14	21.90	11.43	1.92	2.47	1.21	.44	Dk. brown	
G111 1	03	23.07	11.73	1.96	2.55	2.40	.81	Lt. red	St. H.
	1	22.30	11.28	1.97	2.54	2.64	.91	Lt. red	
	3	21.45	11.14	1.98	2.52	3.23	1.11	Lt. red	
	5	21.60	10.89	1.98	2.52	3.35	1.15	Red	
	7	20.50	10.24	2.00	2.52	4.13	1.42	Red	
	9	20.48	10.17	2.01	2.54	4.79	1.63	Red	
	11	20.45	10.11	2.02	2.54	5.42	1.87	Red	
	13	19.01	9.44	2.02	2.49	5.15	1.76	Dk. brown	
	14	12.62	6.13	1.86	2.14	–2.84	–.98	Dk. brown	
G114 1	03	15.64	7.67	2.04	2.42	3.87	1.32	Salmon	St. H.
	1	14.43	6.99	2.06	2.41	4.97	1.70	Lt. red	
	3	12.73	6.16	2.07	2.37	5.16	1.76	Lt. red	
	5	13.51	6.55	2.06	2.37	5.29	1.80	Lt. red	
	7	12.60	6.09	2.07	2.36	5.68	1.94	Red	
	9	14.13	6.77	2.08	2.42	6.04	2.08	Red	
	11	13.43	6.41	2.10	2.42	6.57	2.25	Brown	
	13	13.37	6.35	2.08	2.39	5.68	1.94	Brown	
	14	21.44	12.23	1.76	2.23	–12.35	–4.32	Dk. brown	Bl.

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

TEST HOLES G119, G502-OC, G503-OC

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	Color and remarks
G119 1	03	23.57	13.30	1.92	2.51	-1.52	-.54	Salmon
	3	22.79	11.76	1.93	2.51	-.46	-.17	Salmon St. H.
	5	22.87	11.79	1.94	2.51	-.46	-.17	Lt. red
	7	22.38	11.58	1.93	2.49	-.76	-.27	Lt. red
	9	22.50	11.65	1.93	2.49	-.46	-.17	Red
	11	21.96	11.32	1.94	2.49	-.48	-.17	Reddish gray
	13	22.73	11.82	1.92	2.49	-2.04	-.70	Brown
	14	21.13	10.99	1.92	2.44	-1.97	-.67	Brown
G502 OC	03	27.83	14.72	1.90	2.62	7.27	2.50	Buff St. H.
	1	22.28	11.00	2.03	2.60	12.93	4.54	Salmon
	3	18.06	8.74	2.06	2.52	14.78	5.20	Salmon
	5	18.17	8.79	2.07	2.52	14.89	5.24	Salmon
	7	16.96	8.14	2.08	2.50	15.52	5.50	Salmon
	9	14.12	6.70	2.10	2.45	16.50	5.83	Salmon
	11	11.70	5.52	2.12	2.40	17.04	6.06	Brown
	13	11.66	5.56	2.10	2.37	16.15	5.72	Brown
	14	14.06	6.89	2.04	2.37	14.16	4.98	Brown
G503 OC	03	28.85	15.28	1.89	2.66	6.75	2.32	Buff St. H.
	1	21.68	10.61	2.04	2.61	13.95	4.90	Buff
	3	16.19	7.59	2.13	2.55	17.67	6.29	Salmon
	5	13.08	6.08	2.15	2.47	18.47	6.59	Lt. red
	7	11.83	5.47	2.16	2.45	18.90	6.74	Lt. red
	9	11.26	5.19	2.17	2.43	18.91	6.78	Salmon
	11	10.82	5.00	2.17	2.42	18.97	6.78	Buff
	13	10.50	4.84	2.17	2.42	19.07	6.82	Buff
	14	14.53	7.01	2.07	2.42	15.14	5.35	Brown

Abbreviation: St. H., steel hard.

Modulus of Rupture

Pounds per square inch at cones 03-14

Sample	03	1	3	5	7	9	11	13	14
G10-1	1886	2113	2101	2283	2278	2481	2445	2723	N. D.
G11-1	905	1043	1059	1074	1706	1809	2340	N. D.	N. D.
G12-2	945	1129	1129	1505	1722	1525	1632	1425	
G15-1	1440	2083	2249	3234	3750	3945	2634	1743	2092
G19-1	1720	2139	2583	2603	3033	2904	2826	2979	2840
G20-1	2355	2986	3228	3172	3374	3615	3235	3135	
G27-OC	1358	2257	2944	2821	3273	3342	3456	3605	4511
G27-1	1500	2129	2341	2669	3093	3317	3245	3493	3548
G32-1	816	1722	1690	2179	2196	2354	2309	2361	2961
G33-1	836	1485	1444	2438	2199	2465	1842	2239	1463
G35-1	1435	3202	3662	3777	3692	3807	3409	3258	
G39-1	1963	2247	2251	2328	2320	2321	2254	2609	2444
G41-1	1515	1788	1952	1939	2209	2366	2305	N. D.	N. D.
G42-1	2541	3070	3572	3114	3489	3909	3587	3875	3292
G44-1	1186	2048	2409	2954	3185	3725	3453	4055	3484
G45-2	1432	1334	2070	2479	4170	4545	3633		
G46-1	890	2106	3034	4225	4330	N. D.	N. D.	N. D.	
G57-1	1168	1171	1184	1256	1363	1514	1701	N. D.	N. D.
G62-1-2-3	1568	2105	3513	3488	3784	3869	3523		
G63-1	1232	1201	1277	1426	1692	1627	1577		
G67-1	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.			
G69-1	1071	2145	2938	3012	3081	4311	4423	3992	3516
G71-1	2031	2236	2976	3030	3360	3515	3656	3704	3645
G72-1	1652	2082	N. D.	2368	2503	2517	3076	N. D.	N. D.
G73-2	1829	2074	2461	2513	2777	3066	2929	2188	2363
G78-1	1471	2341	3376	3466	3985	4279	4455	4739	2997
G80-1	1854	2964	3718	4394	4814	5296	5592	4611	
G82-2	1508	1800	1701	1653	2680	2701	3064	2943	3476
G83-1	1489	1735	1555	2014	2758	2871	2806	3429	2709
G87-1	1090	1195	1490	1723	2236	2467	2491	2558	2736
G88-1	1473	1432	1825	2256	2459	2306	2121	2597	2094
G89-1	1271	1663	1623	2721	2872	2943	3007	3481	3629
G90-1	1525	1921	3066	3314	4471	N. D.	N. D.	N. D.	N. D.
G91-2	1896	1843	1812	2778	3753	3924	3802	4134	4002
G91-3	1946	2213	2476	2848	3404	3266	3474	4003	2906
G92-1-2-3	1827	1876	1884	1832	2168	1976	2069	2187	2512
G93-1	1162	1269	1380	1688	1629	1757	2322	2811	2358
G94-1	1887	2589	2452	3311	3904	3689	4021	3114	2841
G94-2	1805	1974	1923	2051	2997	2887	3225	3192	3308
G95-1	1102	1191	1488	1818	N. D.	N. D.	N. D.	N. D.	N. D.
G96-1	1782	1952	1983	2252	2127	2312	2579	3057	
G99-1	1101	2092	3069	3494	4259	4471	4301	4592	4045
G103-1	1903	2136	2402	2902	3343	3726	3992	4382	2877
G104-1	1111	1859	2104	2684	2996	3359	N. D.	N. D.	N. D.
G111-1	1347	1589	1693	1838	1975	2306	2339	2615	1951
G114-1	1227	2332	2484	2557	3286	3126	3076	1779	1781
G119-1	1045	N. D.	1187	1618	1566	1588	1624	1642	1995
G502-OC	1151	2497	2947	2864	4868	4981	4884	4778	2893
G503-OC	1541	1598	1762	1816	3068	3226	3621	2307	1335

POSSIBILITIES FOR UTILIZATION

The brick and tile clays have excellent plastic properties and can be formed into intricate shapes such as silo tile and roofing tile. The linear shrinkage from the plastic to dry state is rather high ranging from 6 to 18 percent, the typical average being about 12 percent. This shrinkage would be considerably less in commercial practice, due to the fact that less water is required to develop the proper plasticity for machine extruded ware. In view of this and the unusually low burning shrinkage over a wide firing range, the total shrinkage is not uncommon and would be satisfactory for heavy clay products. The lowest modulus of rupture value is 340 pounds per square inch and the highest is 1,569 pounds per square inch. The typical average values range between 600 and 900 pounds per square inch. These values are far in excess of those necessary for heavy clay products, consequently the clays could also be used to bond grog and fire clay for the production of sewer pipe and semi-refractory products such as flue lining, chimney block, and low heat duty fire brick and saggers.

These clays generally lie below the loess and surface clays, materials which are considered as being of little economic importance because of their lack of plasticity. In respect to the bond clays, the loess is overburden; however, if a substantial quantity of bond clay is blended with the loess, the resulting mixture would possess all the qualities of a clay suitable for heavy clay products. Experiment has shown that 20, 30, and 40 percent of bond clay blended with loess produces a body sufficiently plastic to be thrown on a potters wheel and formed into articles such as flower pots, vases, and garden pottery.

There is little alteration of the clays on firing from cone 03 through cones 9-14 except in color and strength. In general the porosity and absorption are fairly constant, decreasing slightly at higher temperatures. Some of the clays are more open bodied than others, consequently there is a considerable variety of products that can be produced which require porosity and absorption values in limited ranges. For example, the denser bodied clays are especially suitable for roofing tile, silo tile, and sewer pipe. The more open bodied clays are desirable for use in hollow tile, building brick, and drain tile. Flower pots could be produced from either. It would be difficult to overfire or underfire a kiln of ware made from these clays, a fact which would insure uniform and economical production.

The modulus of rupture values of the fired clays gradually increase from 1100-1800 pounds per square inch at cone 03 to 2000-4700 pounds per square inch at cones 9-14. The fired color gradually darkens from salmon at cone 03 to light red at cones 1, 3, 5, dark red at cones 7-9, and finally to shades of mottled brown at cones 11, 13, and 14 where the clays begin to overburn. Buff burning clays, with shades of salmon and brown, are common to the group. The clear even shades of red and buff are desirable in face brick and other structural products where the ornamental value is important. Multi-colored face brick could be produced by fire flashing.

The clays are rather versatile in their application being suitable for use in the production of building brick and block, partition tile, load bearing tile, silo tile, drain tile, flower pots, sewer pipe, and salt glazed products. Semi-refractory products are possibilities when using the clays as bond.

Individual clays are more desirable for some products than others, but since the general type seems to be present over a wide area, the location of a mine or plant would likely be determined by accessibility, drainage, and overburden.

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		
G8A	1	40.30	62.27	27.76	N. D. Cr.	Greenish gray
G12	1	37.26	58.83	25.65	208 Cr.	Dull gray
G13	OCTR	32.57	55.52	23.71	258 Cr.	Greenish gray
G13	1	32.17	49.43	20.37	667	Greenish gray
G14	1	22.34	31.45	11.85	1012	Neutral gray
G16	1	27.92	36.38	14.00	543	Reddish gray
G21	1	38.80	69.25	32.54	N. D. Cr.	Dull gray
G28	1	33.98	55.80	23.83	293 Cr.	Greenish gray
G28	2	32.79	55.02	23.43	568 Cr.	Greenish gray
G29	1	36.82	57.23	24.70	732 Cr.	Dk. gray
G30	1	31.05	47.48	19.23	149 Cr.	Greenish gray
G31	1	33.12	54.47	23.09	352	Greenish gray
G31	2	39.54	63.68	28.67	110 Cr.	Dull gray
G33	2	31.53	47.05	19.12	974 Cr.	Greenish gray
G34	1	34.75	52.87	22.20	343 Cr.	Yellowish gray
G34	2	43.42	66.10	30.27	894 Cr.	Dk. gray
G36	1	39.40	63.52	28.60	969	Dull gray
G37	1	39.29	63.37	28.47	1338	Dull gray
G40	1	30.24	45.80	18.47	1608	Dull gray
G45	1	28.65	43.43	17.33	636	Greenish gray
G47	1	33.78	55.75	23.83	364 Cr.	Greenish gray
G50	2	26.89	36.27	13.96	950	Neutral gray
G51	1	27.81	38.75	15.10	1242	Yellowish gray
G58	1	33.27	53.15	22.36	N. D. Cr.	Greenish gray
G59	1	31.93	45.23	18.22	844	Greenish gray
G60	1	35.10	44.93	18.07	829	Greenish gray
G61	1	32.15	42.02	16.65	102 Cr.	Greenish gray
G64	1	30.97	49.58	20.42	N. D. Cr.	Greenish gray
G65	1	33.77	47.08	19.12	687 Cr.	Dk. gray
G66	1	30.39	50.40	20.84	130 Cr.	Greenish gray
G68	1	34.98	52.20	21.81	1033	Reddish gray
G70	2	36.55	54.45	23.09	241 Cr.	Greenish gray
G73	1	29.44	43.17	17.18	280	Reddish gray
G75	1	33.36	54.83	23.31	1138	Greenish gray
G76	1	33.84	53.38	22.47	1157	Yellowish gray
G77	1	32.28	46.37	18.77	877	Reddish gray
G81	1	38.48	61.80	27.44	1245 Cr.	Dk. gray
G84	1	33.65	49.58	20.42	1134	Neutral gray
G85	1	36.52	62.68	28.02	701	Yellowish gray
G85	2	37.98	65.65	30.00	425 Cr.	Dull gray
G85	3	32.70	53.02	22.31	1623	Dull gray
G86	1	36.66	58.95	25.71	1135	Greenish gray
G89	2	39.57	61.85	27.50	N. D. Cr.	Dull gray
G97	1	30.38	46.98	19.07	911 Cr.	Reddish gray
G97	2	29.42	48.85	20.05	1178	Neutral gray
G97	3	39.89	62.58	27.95	1093 Cr.	Yellowish gray
G97	4	35.12	58.27	25.29	1187 Cr.	Yellowish gray
G98	1	36.37	59.03	25.77	1430 Cr.	Greenish gray
G98	2	39.67	61.42	27.25	262	Dull gray
G98	3	34.43	56.88	24.46	1462	Neutral gray
G100	1–2	34.20	55.77	23.83	1074	Yellowish gray
G101	1	38.47	64.77	29.39	661 Cr.	Reddish gray

Abbreviation: Cr., cracked; OCTR, outcrop sample.

PHYSICAL PROPERTIES IN THE UNBURNED STATE—(Cont'd.)

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		
G102	1	32.37	53.77	22.69	1531 Cr.	Greenish gray
G102	2	27.86	41.20	16.22	133	Reddish gray
G105	1	37.63	61.08	27.00	1305	Neutral gray
G106	1	36.69	56.37	24.17	465 Cr.	Yellowish gray
G106	2	45.22	72.00	34.58	699 Cr.	Yellowish gray
G107	1	38.40	61.52	27.31	1045	Yellowish gray
G108	1	40.18	55.17	23.48	921	Yellowish gray
G109	1	38.63	58.83	25.65	1244	Greenish gray
G110	1	35.88	51.57	21.49	1469	Yellowish gray
G112	1	50.27	87.08	49.47	374 Cr.	Greenish gray
G113	1	38.88	63.07	28.27	429	Greenish gray
G115	1	34.12	55.03	23.43	815	Yellowish gray
G118	1	33.17	40.45	15.89	686	Dull gray
G118	2	38.12	54.10	22.86	891 Cr.	Dull gray
G120	1	37.20	55.13	23.48	1016 Cr.	Dk. gray
G500	OC	26.98	37.96	14.73	1206	Reddish gray
G501	OC	33.31	51.10	21.22	1157 Cr.	Dull gray

Abbreviation: Cr., cracked; OC, outcrop sample.

SCREEN ANALYSES

(Ground to pass 20-mesh screen)

Sample G8A-1

Retained on screen	Percent	Character of residue
60	6.42	Abundance of limonitic nodules of cemented silt grains.
100	6.60	Abundance of limonitic nodules of cemented silt grains; small amount of quartz.
250	5.16	Abundance of limonitic nodules of cemented silt grains; small amount of quartz.
Cloth	81.82	Clay substance including residue from above.

Sample G14-1

Retained on screen	Percent	Character of residue
60	2.81	Abundance of nodules of cemented opaque silt grains; considerable quantity of earthy hematite.
100	2.82	Abundance of nodules of cemented opaque silt grains; considerable quantity of earthy hematite.
250	8.17	Abundance of nodules of cemented opaque silt grains; considerable quantity of quartz; small amount of earthy hematite.
Cloth	86.20	Clay substance including residue from above.

SAMPLE G16-1

Retained on screen	Percent	Character of residue
60	2.05	Abundance of nodules of cemented opaque silt grains, some stained with limonite; small amount of plant fragments.
100	5.16	Abundance of nodules of cemented opaque silt grains; small amount of earthy hematite.
250	5.80	Abundance of nodules of cemented opaque silt grains; small amounts of hematite and quartz.
Cloth	86.99	Clay substance including residue from above.

SAMPLE G21-1

Retained on screen	Percent	Character of residue
60	2.70	Abundance of nodules of cemented opaque silt grains; small amount of calcareous nodules.
100	4.72	Abundance of nodules of cemented opaque silt grains, some stained with limonite.
250	6.82	Abundance of nodules of cemented opaque silt grains; considerable quantity of quartz.
Cloth	85.76	Clay substance including residue from above.

SAMPLE G31-1

Retained on screen	Percent	Character of residue
60	2.42	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
100	3.68	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; small amount of quartz; trace of ferromanganese material.
250	8.08	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; considerable quantity of quartz.
Cloth	85.82	Clay substance including residue from above.

SAMPLE G36-1

Retained on screen	Percent	Character of residue
60	3.25	Abundance of micaceous gray clay nodules.
100	4.06	Abundance of micaceous limonitic clay nodules; small amount of quartz; trace of ferruginous material.
250	4.08	Abundance of clay nodules; considerable quantity of quartz; trace of ferruginous material.
Cloth	88.61	Clay substance including residue from above.

SAMPLE G40-1

Retained on screen	Percent	Character of residue
60	3.25	Abundance of micaceous gray clay nodules.
100	4.06	Abundance of micaceous gray clay nodules; small amount of quartz; trace of ferruginous material.
250	4.08	Abundance of clay nodules; considerable quantity of quartz; trace of ferruginous material.
Cloth	88.61	Clay substance including residue from above.

SAMPLE G47-1

Retained on screen	Percent	Character of residue
60	3.90	Abundance of quartz; small amount of cemented opaque silt grains.
100	2.41	Abundance of nodules of cemented opaque silt grains, some limonitic stained; considerable quantity of quartz.
250	1.71	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
Cloth	91.98	Clay substance including residue from above.

SAMPLE G50-2

Retained on screen	Percent	Character of residue
60	2.67	Abundance of gray arenaceous clay nodules; small amounts of plant fragments and limonitic stained nodules.
100	2.50	Abundance of gray clay nodules; small amount of limonitic stained nodules.
250	4.54	Abundance of clay nodules; small amounts of quartz and limonitic stained nodules.
Cloth	90.29	Clay substance including residue from above.

SAMPLE G51-1

Retained on screen	Percent	Character of residue
60	5.26	Abundance of nodules of cemented opaque silt grains, some stained with limonite; small amount of plant fragments.
100	4.45	Abundance of nodules of cemented opaque silt grains, some stained with limonite; considerable quantity of quartz.
250	8.89	Abundance of nodules of cemented opaque silt grains, some stained with limonite; considerable quantity of quartz.
Cloth	81.40	Clay substance including residue from above.

SAMPLE G58-1

Retained on screen	Percent	Character of residue
60	1.24	Abundance of quartz; considerable quantity of arenaceous clay nodules.
100	1.11	Abundance of gray waxy clay nodules, some limonitic stained; small amount of quartz.
250	9.83	Abundance of quartz; considerable quantity of clay nodules.
Cloth	87.82	Clay substance including residue from above.

SAMPLE G59-1

Retained on screen	Percent	Character of residue
60	4.53	Abundance of nodules of cemented opaque silt grains; trace of plant fragments.
100	6.22	Abundance of nodules of cemented opaque silt grains, some stained with limonite; small amount of quartz.
250	17.17	Abundance of quartz; considerable quantity of nodules of cemented silt grains, some stained with limonite.
Cloth	72.08	Clay substance including residue from above.

SAMPLF G60-1

Retained on screen	Percent	Character of residue
60	15.43	Abundance of gray waxy clay nodules; considerable quantity of nodules of cemented opaque silt grains; traces of pyrite and limonite.
100	23.39	Abundance of gray waxy clay nodules; considerable quantity of cemented opaque silt grains; traces of pyrite and limonite.
250	18.26	Abundance of gray waxy clay nodules; considerable quantity of nodules of cemented opaque silt grains, some stained with limonite.
Cloth	42.92	Clay substance including residue from above.

SAMPLE G61-1

Retained on screen	Percent	Character of residue
60	6.47	Abundance of micaceous arenaceous clay nodules; small amount of ferruginous nodules.
100	15.31	Abundance of white waxy clay nodules.
250	17.12	Abundance of white waxy clay nodules; small amount of quartz.
Cloth	61.10	Clay substance including residue from above.

SAMPLE G64-1

Retained on screen	Percent	Character of residue
60	2.77	Abundance of limonitic nodules of cemented silt; considerable quantity of quartz.
100	1.99	Abundance of limonitic nodules of cemented silt grains, some not stained; considerable quantity of quartz.
250	2.26	Abundance of limonitic nodules of cemented silt grains, some not stained; considerable quantity of quartz.
Cloth	92.98	Clay substance including residue from above.

SAMPLE G65-1

Retained on screen	Percent	Character of residue
60	7.87	Abundance of nodules of cemented opaque silt grains, small amount stained with limonite.
100	8.69	Abundance of nodules of cemented opaque silt grains, small amount stained with limonite.
250	14.34	Abundance of nodules of cemented opaque silt grains, small amount stained with limonite; small amount of limonitic nodules.
Cloth	69.11	Clay substance including residue from above.

SAMPLE G66-1

Retained on screen	Percent	Character of residue
60	2.81	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; small amount of calcite.
100	4.98	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; trace of calcite.
250	7.57	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; trace of calcite.
Cloth	84.64	Clay substance including residue from above.

SAMPLE G73-1

Retained on screen	Percent	Character of residue
60	7.97	Abundance of nodules of cemented opaque silt grains; considerable quantity of earthy hematite.
100	7.70	Abundance of nodules of cemented opaque silt grains; considerable quantity of earthy hematite; small amount of quartz.
250	11.15	Abundance of nodules of cemented opaque silt grains; considerable quantity of quartz; small amount of earthy hematite.
Cloth	73.18	Clay substance including residue from above.

SAMPLE G75-1

Retained on screen	Percent	Character of residue
60	4.42	Abundance of limonitic stained nodules of arenaceous clay.
100	2.43	Abundance of limonitic stained nodules of arenaceous clay; small amount of quartz.
250	3.23	Abundance of limonitic stained nodules of clay.
Cloth	89.92	Clay substance including residue from above.

SAMPLE G76-1

Retained on screen	Percent	Character of residue
60	2.90	Abundance of limonitic nodules of cemented silt grains.
100	2.25	Abundance of limonitic nodules of cemented silt grains.
250	2.99	Abundance of limonitic nodules of cemented silt grains.
Cloth	91.86	Clay substance including residue from above.

SAMPLE G77-1

Retained on screen	Percent	Character of residue
60	13.92	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
100	10.04	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
250	11.52	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
Cloth	64.52	Clay substance including residue from above.

SAMPLE G81-1

Retained on screen	Percent	Character of residue
60	6.03	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
100	5.55	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
250	3.67	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
Cloth	84.75	Clay substance including residue from above.

SAMPLE G84-1

Retained on screen	Percent	Character of residue
60	4.19	Abundance of arenaceous clay nodules; considerable quantity of earthy hematite; small amount of quartz.
100	4.85	Abundance of limonitic stained clay nodules, some gray nodules; considerable quantity of quartz; small amount of earthy hematite.
250	7.63	Abundance of gray clay nodules, some stained with limonite; small amount of quartz.
Cloth	83.33	Clay substance including residue from above.

SAMPLE G85-1

Retained on screen	Percent	Character of residue
60	5.47	Abundance of limonitic nodules of cemented silt grains, some not stained, some gray.
100	5.74	Abundance of limonitic nodules of cemented silt grains, some not stained, some gray; trace of ferruginous material.
250	9.13	Abundance of limonitic nodules of cemented silt grains, some not stained, some gray; small amount of quartz.
Cloth	79.66	Clay substance including residue from above.

Sample G85-2

Retained on screen	Percent	Character of residue
60	.63	Abundance of nodules of cemented opaque silt grains, some stained with limonite; small amount of quartz; traces of gypsum and pyrite.
100	1.18	Abundance of nodules of cemented opaque silt grains, some stained with limonite; considerable quantity of quartz; trace of pyrite.
250	2.37	Abundance of nodules of cemented opaque silt grains, some stained with limonite; considerable quantity of quartz.
Cloth	95.82	Clay substance including residue from above.

Sample G85-3

Retained on screen	Percent	Character of residue
60	1.10	Abundance of nodules of cemented opaque silt grains; small amount stained with limonite.
100	2.66	Abundance of nodules of cemented opaque silt grains; some stained with limonite; small amount of quartz.
250	1.95	Abundance of nodules of cemented opaque silt grains; some stained with limonite; small amount of quartz.
Cloth	94.89	Clay substance including residue from above.

Sample G105-1

Retained on screen	Percent	Character of residue
60	1.04	Abundance of gray arenaceous clay nodules; considerable quantity of earthy hematite.
100	2.34	Abundance of gray clay nodules; small amounts of quartz and limonitic nodules.
250	3.95	Abundance of clay nodules; considerable quantities of quartz and limonitic stained clay nodules; small amount of ferruginous material.
Cloth	92.67	Clay substance including residue from above.

Sample G106-1

Retained on screen	Percent	Character of residue
60	4.35	Abundance of nodules of cemented opaque silt grains, some stained with limonite.
100	6.41	Abundance of nodules of cemented opaque silt grains, some stained with limonite.
250	8.93	Abundance of nodules of cemented opaque silt grains, some stained with limonite.
Cloth	80.31	Clay substance including residue from above.

Sample G106-2

Retained on screen	Percent	Character of residue
60	1.30	Abundance of limonitic stained nodules of cemented silt grains.
100	4.73	Abundance of limonitic stained nodules of cemented silt grains.
250	5.65	Abundance of limonitic stained nodules of cemented silt grains.
Cloth	88.32	Clay substance including residue from above.

Sample G107-1

Retained on screen	Percent	Character of residue
60	4.16	Abundance of gray clay nodules; considerable quantity of limonitic clay nodules; small amount of quartz; trace of ferruginous material.
100	2.48	Abundance of limonitic clay nodules; considerable quantity of gray clay nodules; small amount of quartz.
250	8.82	Abundance of limonitic clay nodules; considerable quantity of gray clay nodules; small amount of quartz.
Cloth	84.54	Clay substance including residue from above.

SAMPLE G108-1

Retained on screen	Percent	Character of residue
60	2.35	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
100	3.28	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
250	6.94	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite.
Cloth	87.43	Clay substance including residue from above.

SAMPLE G109-1

Retained on screen	Percent	Character of residue
60	5.17	Abundance of limonitic stained nodules of cemented silt grains; small amount of calcite nodules.
100	5.81	Abundance of limonitic stained nodules of cemented silt grains; small amount of calcite nodules; trace of ferruginous material.
250	6.09	Abundance of limonitic nodules of cemented silt grains; trace of ferruginous material.
Cloth	82.93	Clay substance including residue from above.

SAMPLE G110-1

Retained on screen	Percent	Character of residue
60	5.35	Abundance of limonitic stained arenaceous nodules; small amount of arenaceous clay nodules.
100	6.51	Abundance of limonitic stained clay nodules, some not stained.
250	7.91	Abundance of limonitic clay nodules, some not stained.
Cloth	80.43	Clay substance including residue from above.

SAMPLE G112-1

Retained on screen	Percent	Character of residue
60	4.54	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; considerable quantity of quartz.
100	5.16	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; considerable quantity of quartz.
250	6.28	Abundance of nodules of cemented opaque silt grains; considerable quantity stained with limonite; considerable quantity of quartz.
Cloth	83.02	Clay substance including residue from above.

SAMPLE G113-1

Retained on screen	Percent	Character of residue
60	4.91	Abundance of nodules of cemented opaque silt grains; small amount of quartz; trace of limonite.
100	6.35	Abundance of nodules of cemented opaque silt grains; small amount of quartz; trace of limonite.
250	7.38	Abundance of nodules of cemented opaque silt grains; small amounts of quartz and limonite.
Cloth	81.36	Clay substance including residue from above.

SAMPLE G120-1

Retained on screen	Percent	Character of residue
60	13.71	Abundance of gray waxy clay nodules, some stained with limonite.
100	21.33	Abundance of gray waxy clay nodules, some stained with limonite.
250	19.49	Abundance of gray waxy clay nodules, some stained with limonite.
Cloth	46.47	Clay substance including residue from above.

SAMPLE G500-OC

Retained on screen	Percent	Character of residue
60	10.14	Abundance of nodules of cemented opaque silt grains; small amount of earthy hematite.
100	12.17	Abundance of nodules of cemented opaque silt grains; small amount of earthy hematite.
250	12.73	Abundance of nodules of cemented opaque silt grains; small amount of quartz and earthy hematite.
Cloth	64.94	Clay substance including residue from above.

SAMPLE G501-OC

Retained on screen	Percent	Character of residue
60	5.07	Abundance of arenaceous gray clay nodules, some limonitic stained.
100	2.93	Abundance of arenaceous gray clay nodules, some limonitic stained.
250	10.37	Abundance of gray clay nodules; small amounts of quartz and limonitic stained clay.
Cloth	81.63	Clay substance including residue from above.

Alta Ray Gault, technician.

CHEMICAL ANALYSES[*]

SAMPLE G8A-1

Ignition loss	9.09	Titania, TiO_2	1.16	Manganese, MnO_2	None
Silica, SiO_2	59.79	Lime, CaO	1.05	Alkalies, (K_2O, Na_2O)	0.31
Alumina, Al_2O_3	24.06	Magnesia, MgO	0.40		
Iron oxide, Fe_2O_3	3.76				

Soluble Silica in 10 percent Na_2CO_3 solution .... 13.95 percent

SAMPLE G14-1

Ignition loss	6.09	Titania, TiO_2	0.68	Manganese, MnO_2	Trace
Silica, SiO_2	68.13	Lime, CaO	0.92	Alkalies, (K_2O, Na_2O)	Trace
Alumina, Al_2O_3	18.90	Magnesia, MgO	0.60		
Iron oxide, Fe_2O_3	4.50				

Soluble Silica in 10 percent Na_2CO_3 solution .... 5.52 percent

SAMPLE G16-1

Ignition loss	6.01	Titania, TiO_2	1.26	Manganese, MnO_2	Trace
Silica, SiO_2	72.56	Lime, CaO	1.68	Alkalies, (K_2O, Na_2O)	0.63
Alumina, Al_2O_3	12.54	Magnesia, MgO	1.25		
Iron oxide, Fe_2O_3	3.56				

Soluble Silica in 10 percent Na_2CO_3 solution .... 1.76 percent

SAMPLE G21-1

Ignition loss 11.86	Titania, TiO_2 .... 0.70	Manganese, MnO_2 Trace
Silica, SiO_2 .... 59.99	Lime, CaO 0.99	Alkalies, (K_2O,
Alumina, Al_2O_3 .... 20.66	Magnesia, MgO 0.34	Na_2O) 1.29
Iron oxide, Fe_2O_3 ... 3.90		

Soluble Silica in 10 percent Na_2CO_3 solution .... 13.95 percent

SAMPLE G31-1

Ignition loss 6.93	Titania, TiO_2 .... 0.58	Manganese, MnO_2 Trace
Silica, SiO_2 .... 66.80	Lime, CaO 1.66	Alkalies, (K_2O,
Alumina, Al_2O_3 .... 16.63	Magnesia, MgO 1.47	Na_2O) 0.23
Iron oxide, Fe_2O_3 ... 5.88		

Soluble Silica in 10 percent Na_2CO_3 solution .... 7.67 percent

SAMPLE G36-1

Ignition loss 6.87	Titania, TiO_2 .... 0.68	Manganese, MnO_2 Trace
Silica, SiO_2 .... 61.99	Lime, CaO 1.12	Alkalies, (K_2O,
Alumina, Al_2O_3 .... 22.08	Magnesia, MgO 1.55	Na_2O) 0.42
Iron oxide, Fe_2O_3 ... 5.78		

Soluble Silica in 10 percent Na_2CO_3 solution .... 7.07 percent

SAMPLE G40-1

Ignition loss 7.63	Titania, TiO_2 .... 1.26	Manganese, MnO_2 None
Silica, SiO_2 .... 67.60	Lime, CaO 1.59	Alkalies, (K_2O,
Alumina, Al_2O_3 .... 15.58	Magnesia MgO 0.70	Na_2O) 0.47
Iron oxide, Fe_2O_3 ... 4.94		

Soluble Silica in 10 percent Na_2CO_3 solution .... 5.59 percent

SAMPLE G50-2

Ignition loss 8.24	Titania, TiO_2 .... 0.34	Manganese, MnO_2 Trace
Silica, SiO_2 .... 65.04	Lime, CaO 0.85	Alkalies, (K_2O,
Alumina, Al_2O_3 .... 20.55	Magnesia, MgO 0.57	Na_2O) .... None
Iron oxide, Fe_2O_3 ... 4.50		

Soluble Silica in 10 percent Na_2CO_3 solution .... 7.82 percent

SAMPLE G51-1

Ignition loss 6.63	Titania, TiO_2 .... 0.83	Manganese, MnO_2 Trace
Silica, SiO_2 .... 66.95	Lime, CaO 0.66	Alkalies, (K_2O,
Alumina, Al_2O_3 .... 19.27	Magnesia, MgO 0.69	Na_2O) 0.65
Iron oxide, Fe_2O_3 ... 3.50		

Soluble Silica in 10 percent Na_2CO_3 solution .... 12.11 percent

SAMPLE G58-1

Ignition loss 8.29	Titania, TiO_2 .... 1.08	Manganese, MnO_2 Trace
Silica, SiO_2 .... 64.03	Lime, CaO 0.60	Alkalies, (K_2O,
Alumina, Al_2O_3 .... 21.93	Magnesia, MgO 0.44	Na_2O) 0.13
Iron oxide, Fe_2O_3 ... 3.37		

Soluble Silica in 10 percent Na_2CO_3 solution .... 6.09 percent

SAMPLE G64-1

Ignition loss	8.09	Titania, TiO_2	1.02	Manganese, MnO_2	Trace
Silica, SiO_2	69.49	Lime, CaO	1.00	Alkalies, (K_2O, Na_2O)	0.96
Alumina, Al_2O_3	14.82	Magnesia, MgO	0.51		
Iron oxide, Fe_2O_3	4.38				

Soluble Silica in 10 percent Na_2CO_3 solution .... 5.38 percent

SAMPLE G73-1

Ignition loss	7.88	Titania, TiO_2	1.45	Manganese, MnO_2	Trace
Silica, SiO_2	62.56	Lime, CaO	1.69	Alkalies, (K_2O, Na_2O)	0.14
Alumina, Al_2O_3	20.37	Magnesia, MgO	None		
Iron oxide, Fe_2O_3	5.31				

Soluble Silica in 10 percent Na_2CO_3 solution .... 7.30 percent

SAMPLE G75-1

Ignition loss	6.32	Iron oxide, Fe_2O_3	6.99	Magnesia, MgO	None
Silica, SiO_2	64.36	Titania, TiO_2	1.55	Manganese, MnO_2	Trace
Alumina, Al_2O_3	18.35	Lime, CaO	0.95	Alkalies, (K_2O, Na_2O)	0.53

Soluble Silica in 10 percent Na_2CO_3 solution .... 10.57 percent

SAMPLE G76-1

Ignition loss	6.95	Iron oxide, Fe_2O_3	4.85	Magnesia, MgO	0.85
Silica, SiO_2	63.12	Titania, TiO_2	1.28	Manganese, MnO_2	Trace
Alumina, Al_2O_3	20.46	Lime, CaO	0.59	Alkalies, (K_2O, Na_2O)	0.20

Soluble Silica in 10 percent Na_2CO_3 solution .... 9.42 percent

SAMPLE G77-1

Ignition loss	6.13	Iron oxide, Fe_2O_3	6.97	Magnesia, MgO	0.44
Silica, SiO_2	68.48	Titania, TiO_2	0.95	Manganese, MnO_2	Trace
Alumina, Al_2O_3	16.02	Lime, CaO	0.51	Alkalies, (K_2O, Na_2O)	0.30

Soluble Silica in 10 percent Na_2CO_3 solution .... 18.03 percent

SAMPLE G81-1

Ignition loss	6.70	Iron oxide, Fe_2O_3	6.42	Magnesia, MgO	1.09
Silica, SiO_2	65.19	Titania, TiO_2	1.33	Manganese, MnO_2	Trace
Alumina, Al_2O_3	17.04	Lime, CaO	0.72	Alkalies, (K_2O, Na_2O)	0.26

Soluble Silica in 10 percent Na_2CO_3 solution .... 2.85 percent

SAMPLE G84-1

Ignition loss	6.75	Iron oxide, Fe_2O_3	3.61	Magnesia, MgO	0.81
Silica, SiO_2	65.78	Titania, TiO_2	2.25	Manganese, MnO_2	Trace
Alumina, Al_2O_3	18.43	Lime, CaO	0.66	Alkalies, (K_2O, Na_2O)	0.83

Soluble Silica in 10 percent Na_2CO_3 solution .... 11.44 percent

SAMPLE G85-2

Ignition loss 6.64	Iron oxide, Fe_2O_3 ... 4.80	Magnesia, MgO 1.34
Silica, SiO_2 ....68.55	Titania, TiO_2 .... 2.10	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ......13.77	Lime, CaO 3.09	Alkalies, (K_2O, Na_2O) 0.14

Soluble Silica in 10 percent Na_2CO_3 solution .... 6.86 percent

SAMPLE G106-1

Ignition loss 7.16	Iron oxide, Fe_2O_3 ... 3.85	Magnesia, MgO 1.49
Silica, SiO_2 ....61.73	Titania, TiO_2 .... 1.14	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ......20.12	Lime, CaO 3.13	Alkalies, (K_2O, Na_2O) 0.34

Soluble Silica in 10 percent Na_2CO_3 solution .... 7.74 percent

SAMPLE G110-1

Ignition loss 6.53	Iron oxide, Fe_2O_3 ... 4.82	Magnesia, MgO 0.77
Silica, SiO_2 ....63.81	Titania, TiO_2 .... 2.04	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ......20.25	Lime, CaO 1.10	Alkalies, (K_2O, Na_2O) 0.35

Soluble Silica in 10 percent Na_2CO_3 solution .... 10.56 percent

SAMPLE G113-1

Ignition loss 8.26	Iron oxide, Fe_2O_3 ... 4.45	Magnesia, MgO 1.39
Silica, SiO_2 ....59.72	Titania, TiO_2 .... 0.54	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ......19.36	Lime, CaO 5.19	Alkalies, (K_2O, Na_2O) 0.39

Soluble Silica in 10 percent Na_2CO_3 solution .... 13.56 percent

SAMPLE G500-OC

Ignition loss 5.83	Iron oxide, Fe_2O_3 ... 2.67	Magnesia, MgO 0.53
Silica, SiO_2 ....69.95	Titania, TiO_2 .... 0.72	Manganese, MnO_2 Trace
Alumina, Al_2O_3 ......18.32	Lime, CaO 0.53	Alkalies, (K_2O, Na_2O) 0.44

Soluble Silica in 10 percent Na_2CO_3 solution .... 8.74 percent

* Analyses of residue washed through 250 mesh screen.

B. F. Mandlebaum, analyst.

PYRO-PHYSICAL PROPERTIES

Fired to cone 03

Hole No.	Sample No.	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
G8A	1	5.50	2.96	1.86	1.97	1.77	.60	Lt. red	Cr., St. H.
G12	1	5.87	2.77	2.12	2.25	15.40	5.42	Salmon	Cr., St. H.
G13	OCTR	13.79	6.52	2.12	2.45	9.57	3.31	Salmon	Cr., St. H.
G13	1	15.38	7.41	2.08	2.45	7.92	2.74	Salmon	Cr., St. H.
G14	1	17.67	8.56	2.06	2.51	3.74	1.28	Salmon	Cr., St. H.
G16	1	20.89	10.51	1.99	2.51	6.64	2.29	Buff	Cr., St. H.
G21	1	4.87	2.23	2.19	2.30	19.30	6.90	Salmon	Cr., St. H.
G28	1	2.93	1.27	2.31	2.38	20.36	7.32	Salmon	Cr., St. H.
G28	2	3.32	1.46	2.27	2.34	19.83	7.13	Lt. red	Cr., St. H.
G29	1	18.35	10.41	1.76	2.16	.00	.00	Salmon	Cr., St. H.
G30	1	9.09	4.23	2.15	2.37	13.33	4.68	Salmon	Cr., St. H.
G31	1	13.88	6.67	2.08	2.41	7.18	2.46	Salmon	Cr., St. H.
G31	2	8.36	3.94	2.12	2.32	14.14	4.98	Salmon	Cr., St. H.
G33	2	7.25	3.27	2.22	2.40	17.83	6.36	Salmon	Cr., St. H.
G34	1	3.02	1.36	2.22	2.29	18.60	6.63	Salmon	Cr., St. H.
G34	2	25.23	15.52	1.63	2.18	–7.58	–2.60	Salmon	Cr., St. H.
G36	1	2.77	1.23	2.12	2.52	12.46	4.35	Lt. red	Cr., St. H.
G37	1	6.27	2.96	2.12	2.26	11.65	4.06	Salmon	Cr., St. H.
G40	1	17.82	8.81	2.02	2.46	8.34	2.88	Buff	Cr., St. H.
G45	1	12.39	5.91	2.10	2.39	9.09	3.13	Salmon	Cr., St. H.
G47	1	3.77	1.64	2.30	2.38	22.87	8.30	Salmon	Cr., St. H.
G50	2	19.23	9.53	2.02	2.49	9.82	3.42	Salmon	Cr., St. H.
G51	1	20.12	10.33	1.97	2.37	8.17	2.81	Salmon	Cr., St. H.
G58	1	12.59	6.07	2.07	2.37	9.66	3.34	Salmon	Cr., St. H.
G59	1	13.94	12.32	1.94	2.55	5.86	2.01	Salmon	Cr., St. H.
G60	1	10.71	4.87	2.20	2.46	20.43	7.36	Salmon	Cr., St. H.
G61	1	19.54	9.69	2.02	2.51	10.50	3.63	Salmon	Cr., St. H.
G64	1	11.94	5.69	2.10	2.39	9.98	3.45	Salmon	Cr., St. H.
G65	1	18.79	9.18	2.05	2.52	14.10	4.94	Salmon	Cr., St. H.
G66	1	12.23	5.71	2.14	2.44	11.48	3.99	Salmon	Cr., St. H.
G68	1	17.17	8.72	2.04	2.46	16.08	5.68	Salmon	Cr., St. H.
G70	2	9.46	4.51	2.10	2.32	14.68	5.16	Salmon	Cr., St. H.
G73	1	16.16	7.78	2.08	2.48	12.49	4.35	Salmon	Cr., St. H.
G75	1	4.39	1.95	2.25	2.36	17.89	6.36	Lt. red	Cr., St. H.
G76	1	13.93	7.18	2.14	2.49	12.36	4.32	Lt. red	Cr., St. H.
G77	1	19.99	10.09	2.02	2.53	10.23	3.57	Salmon	Cr., St. H.
G81	1	4.98	2.25	2.22	2.34	17.24	6.14	Salmon	Cr., St. H.
G84	1	19.47	9.55	2.04	2.53	9.71	3.38	Salmon	Cr., St. H.
G85	1	11.62	5.88	1.98	2.57	4.94	1.70	Lt. red	Cr., St. H.
G85	2	13.07	6.17	2.11	2.43	11.06	3.85	Salmon	Cr., St. H.
G85	3	15.06	7.17	2.10	2.47	10.45	3.63	Salmon	Cr., St. H.
G86	1	9.39	4.21	2.23	2.46	17.57	6.25	Salmon	Cr., St. H.
G89	2	2.87	1.27	2.26	2.33	20.44	7.36	Salmon	Cr., St. H.
G97	1	19.17	9.19	2.09	2.58	12.47	4.35	Salmon	Cr., St. H.
G97	2	13.12	6.14	2.14	2.46	11.21	3.92	Salmon	Cr., St. H.
G97	3	3.25	1.40	2.32	2.40	23.36	8.50	Lt. red	Cr., St. H.
G97	4	16.66	8.98	1.86	2.23	4.14	1.42	Lt. red	Cr., St. H.
G98	1	11.90	5.46	2.18	2.47	13.93	4.90	Lt. red	Cr., St. H.
G98	2	8.67	3.92	2.21	2.42	18.87	6.74	Salmon	Cr., St. H.
G98	3	12.46	5.76	2.16	2.47	13.68	4.79	Salmon	Cr., St. H.

Abbreviations: Cr., cracked; St. H., steel hard; OCTR, outcrop sample.

Fired to cone 03

Hole No.	Sample No.	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
G100	1–2	13.93	6.56	2.12	2.47	9.64	3.34	Salmon	Cr., St. H.
G101	1	7.17	3.23	2.22	2.40	18.77	6.71	Salmon	Cr., St. H.
G102	1	19.91	9.95	2.02	2.52	4.45	1.52	Salmon	Cr., St. H.
G102	2	20.39	10.00	2.03	2.56	6.75	2.32	Salmon	Cr., St. H.
G105	1	10.82	4.87	2.22	2.49	14.96	5.27	Salmon	Cr., St. H.
G106	1	6.72	2.98	2.25	2.41	18.92	6.78	Lt. red	Cr., St. H.
G106	2	2.89	1.18	2.42	2.49	26.57	9.79	Lt. red	Cr., St. H.
G107	1	12.10	5.55	2.18	2.48	16.14	5.72	Salmon	Cr., St. H.
G108	1	2.44	1.05	2.34	2.39	24.44	8.94	Salmon	Cr., St. H.
G109	1	21.17	11.34	1.87	2.37	5.64	1.94	Lt. red	Cr., St. H.
G110	1	13.89	6.41	2.17	2.51	16.34	5.80	Salmon	Cr., St. H.
G112	1	2.88	1.25	2.30	2.37	21.47	7.75	Salmon	Cr., St. H.
G113	1	4.47	2.04	2.19	2.29	16.99	6.02	Salmon	Cr., St. H.
G115	1	15.79	7.56	2.09	2.48	7.66	2.64	Lt. red	Cr., St. H.
G118	1	24.55	12.48	1.97	2.61	10.55	3.67	Buff	Cr., St. H.
G118	2	21.25	10.62	2.02	2.56	12.83	4.50	Buff	Cr., St. H.
G120	1	3.00	1.34	2.23	2.30	20.34	7.34	Salmon	Cr., St. H.
G500	OC	21.87	10.91	2.00	2.56	6.41	2.22	Buff	Cr., St. H.
G501	OC	11.24	5.34	2.11	2.37	14.23	5.01	Salmon	Cr., St. H.

Abbreviations: Cr., cracked; St. H., steel hard; OC, outcrop sample.

PROPERTIES OF BOND CLAY AND GROG BODY MIXTURES

50 percent bond clay and 50 percent—⅛ inch mesh fire clay grog

Hole No.	Sample No.	Unburned		Burned at cone 10	
		Linear shrinkage percent	Modulus of rupture in pounds per square inch	Total linear shrinkage percent	Modulus of rupture in pounds per square inch
G8A	1	6.8	453	9.8	1137
G13	OCTR	6.3	519	7.5	928
G13	1	5.8	434	7.2	824
G14	1	5.3	614	6.5	925
G16	1	6.0	655	7.5	762
G21	1	7.3	415	8.8	541
G28	1	6.3	573	8.5	941
G28	2	7.3	540	9.5	1147
G29	1	5.8	521	Bars melted on firing	
G30	1	6.7	527	8.3	898
G31	1	5.7	600	7.3	839
G31	2	5.7	393	7.3	718
G33	2	6.5	504	8.8	1048
G34	1	6.3	601	8.8	936
G34	2	6.5	385	8.8	1323
G36	1	6.8	497	9.3	1252
G37	1	6.5	704	9.5	1245
G40	1	6.5	500	7.2	762
G45	1	6.5	448	8.2	797
G47	1	6.5	443	9.0	849
G50	2	5.8	542	8.0	1054
G51	1	5.8	537	7.5	792
G58	1	5.2	476	5.8	748
G59	1	5.3	463	6.0	577
G60	1	5.5	317	7.8	973
G64	1	6.0	560	7.3	918
G65	1	6.0	485	8.7	1091
G66	1	5.8	575	8.0	1100
G68	1	5.7	471	8.7	957
G70	2	6.5	516	8.5	1109
G73	1	6.0	564	8.2	975
G75	1	5.5	470	6.3	776
G76	1	4.7	466	6.3	947
G77	1	5.5	440	7.2	713
G81	1	5.7	356	Bars melted on firing	
G84	1	5.0	513	6.8	860
G85	1	5.5	523	6.8	791
G85	2	6.0	512	6.8	797
G85	3	4.8	559	6.5	970
G86	1	6.3	516	8.7	773
G89	2	7.0	343	9.2	570
G97	1	6.5	345	7.7	559
G97	2	6.2	466	7.2	905
G97	3	6.5	609	8.2	1157
G97	4	7.0	430	Bars melted on firing	
G98	1	6.7	539	8.3	848
G98	2	6.3	439	8.5	764
G98	3	5.3	433	7.0	815
G100	1-2	5.5	472	6.7	765
G101	1	5.8	385	7.5	641
G102	1	5.3	489	5.8	732

Abbreviation: OCTR, outcrop sample.

50 percent bond clay and 50 percent—⅛ inch mesh fire clay grog

Hole No.	Sample No.	Unburned		Burned at cone 10	
		Linear shrinkage percent	Modulus of rupture in pounds per square inch	Total linear shrinkage percent	Modulus of rupture in pounds per square inch
G102	2	4.0	343	4.7	851
G105	1	5.5	544	6.8	975
G106	1	6.3	468	8.0	839
G106	2	6.5	325	8.8	640
G107	1	7.5	474	9.3	916
G108	1	5.5	420	7.7	1044
G109	1	6.7	484	8.5	862
G110	1	5.2	555	7.0	1172
G112	1	6.0	465	8.5	796
G113	1	7.0	461	9.2	725
G115	1	5.2	572	6.8	966
G118	1	5.3	416	7.0	713
G118	2	6.5	502	8.7	962
G120	1	7.7	307	8.3	644
G500	OC	6.2	519	7.5	1057
G501	OC	6.2	453	7.3	834

Abbreviation: OC, outcrop sample.

THIXOTROPIC PROPERTIES OF BOND CLAYS

TABLE I—PARTS BY WEIGHT: CLAY 33.33, WATER, 66.66

Sample	pH	Stormer viscosity Imm.	Stormer Gel strength		Mud weight		
			Imm.	15 Min.	Specific gravity	Pounds per gallon	Hydr. pres. 100 ft.
G8A	6.22	6.75	11	15	1.25	10.43	54.19
G11-1	6.11	2.50	5	4	1.20	10.01	52.02
G14-1	6.09	4.00	6	7	1.20	10.01	52.02
G16-1	6.19	6.75	3	3	1.20	10.01	52.02
G21-1	6.52	15.00	17	21	1.24	10.35	53.74
G31-1	6.79	4.75	1	2	1.15	9.60	49.85
G35-1	7.46	4.25	3	9	1.21	10.10	52.45
G36-1	6.50	12.00	18	26	1.21	10.10	52.45
G40-1	6.64	5.90	5	6	1.23	10.26	53.32
G42-1	7.42	4.00	5	6	1.22	10.18	52.89
G50-2	6.51	7.50	3	5	1.18	9.85	51.15
G51-1	6.58	4.00	8	10	1.19	9.93	51.59
G58-1	7.42	6.00	4	9	1.20	10.01	52.02
G64-1	5.52	7.00	6	36	1.22	10.18	52.89
G73-1	5.45	7.30	6	8	1.19	9.93	51.59
G75-1	7.00	6.75	1	1	1.20	10.01	52.02
G76-1	7.01	8.00	6	8	1.21	10.10	52.45
G77-1	6.10	4.25	3	2	1.23	10.26	53.32
G78-1	6.28	4.75	1	4	1.21	10.10	52.45
G81-1	5.99	9.00	5	5	1.24	10.35	53.74
G83-1	7.00	4.75	5	6	1.20	10.01	52.02
G84-1	6.54	3.50	4	6	1.18	9.85	51.15
G85-2	6.37	6.75	5	6	1.17	9.76	50.72
G106-1	6.82	6.75	6	8	1.18	9.85	51.15
G110-1	7.15	8.20	7	12	1.27	10.60	55.05
G113-1	7.00	7.85	6	6	1.23	10.26	53.32
G500-OC	6.61	4.75	3	6	1.18	9.85	51.15

TABLE II—PARTS BY WEIGHT: CLAY 20.0, WATER 80.0, NaOH 0.16

Sample	pH	Stormer viscosity Imm.	Stormer Gel strength		Mud weight			Residue* on No. 250 screen
			Imm.	15 Min.	Specific gravity	Pounds per gallon	Hydr. pres. 100 ft.	
G8A	11.20	7.20	5	13	1.14	9.51	49.42	1.11
G11-1	11.93	4.00	10	14	1.08	9.02	46.82	7.70
G14-1	11.52	13.60	13	51	1.08	9.02	46.82	5.77
G16-1	10.93	6.75	3	36	1.12	9.35	48.55	2.84
G21-1	10.67	6.75	4	6	1.10	9.18	47.69	1.37
G31-1	11.20	7.90	5	16	1.09	9.10	47.25	4.64
G35-1	11.31	3.75	2	4	1.09	9.10	47.25	9.10
G36-1	10.35	7.75	4	8	1.11	9.26	48.12	1.88
G40-1	11.48	14.50	26	106	1.12	9.35	48.55	3.23
G42-1	11.00	4.00	11	23	1.03	8.60	44.65	3.20
G50-2	11.30	12.50	8	28	1.11	9.26	48.12	3.07
G51-1	10.99	7.50	6	8	1.09	9.10	47.25	5.94
G58-1	10.92	15.50	4	6	1.10	9.18	47.69	8.57
G64-1	10.77	47.15	14	106	1.13	9.43	48.99	4.16
G73-1	10.90	20.10	5	31	1.10	9.18	47.69	9.55
G75-1	11.22	7.50	2	8	1.12	9.35	48.55	0.39
G76-1	11.50	9.50	17	54	1.13	9.43	48.99	0.24
G77-1	11.07	7.90	4	7	1.08	9.02	46.82	6.36
G78-1	11.31	8.90	6	6	1.10	9.18	47.69	5.99
G81-1	10.90	10.50	4	5	1.11	9.26	48.12	1.10
G83-1	11.53	8.00	13	46	1.10	9.18	47.69	6.85
G84-1	11.40	6.50	5	16	1.11	9.26	48.12	5.00
G85-2	11.02	39.00	11	101	1.11	9.26	48.12	1.98
G106-1	11.82	6.00	5	16	1.12	9.35	48.55	0.88
G110-1	11.65	4.00	6	10	1.12	9.35	48.55	1.11
G113-1	10.91	10.00	3	5	1.10	9.18	47.69	3.00
G500-OC	11.40	10.00	15	46	1.08	9.02	46.82	5.88

* Values are the percent of residue retained on 250 mesh screen based on 100 percent dry clay. The residue is sand and silt.

PROPERTIES OF DRILLING MUD FROM BOND CLAYS

Sample G40-1

Parts by weight			Pounds of NaOH per ton of clay	pH	Stormer viscosity Imm.	Stormer Gel strength		Mud weight	
Clay	Water	NaOH				Imm.	15 Min.	Specific gravity	Pounds per gallon
20.0	80.0	0.00	0.00	6.95	1.60	1	1	1.09	9.10
20.0	80.0	0.02	2.00	7.22	1.60	1	1	1.03	8.60
20.0	80.0	0.04	4.00	7.90	2.40	1	1	1.07	8.93
20.0	80.0	0.06	6.00	8.22	3.50	1	1	1.08	9.02
20.0	80.0	0.08	8.00	9.26	5.75	2	2	1.05	8.76
20.0	80.0	0.10	10.00	10.20	7.50	2	3	1.10	9.18
20.0	80.0	0.12	12.00	10.70	11.25	15	41	1.11	9.26
20.0	80.0	0.14	14.00	11.01	25.50	24	130	1.12	9.35
15.0	85.0	0.105	14.00	9.02	7.75	6	36	1.07	8.93
15.0	85.0	0.120	16.00	10.68	9.00	16	121	1.08	9.02
15.0	85.0	0.135	18.00	10.28	17.50	71	151	1.11	9.26
12.5	87.5	0.111	18.00	8.41	6.75	5	14	1.06	8.85
12.5	87.5	0.125	20.00	10.37	7.75	4	51	1.06	8.85
12.5	87.5	0.138	22.00	11.44	10.00	20	131	1.06	8.85
12.5	87.5	0.150	24.00	11.52	13.60	61	161	1.06	8.85
10.0	90.0	0.120	24.00	11.45	5.00	2	34	1.03	8.60
10.0	90.0	0.130	26.00	11.50	5.00	4	41	1.03	8.60
10.0	90.0	0.140	28.00	11.61	5.00	14	64	1.04	8.68
10.0	90.0	0.150	30.00	11.60	7.75	24	71	1.05	8.76
10.0	90.0	0.160	32.00	11.67	8.25	28	76	1.04	8.68
10.0	90.0	0.170	34.00	11.72	8.25	34	74	1.03	8.60

Sample G85-2

Parts by weight			Pounds of NaOH per ton of clay	pH	Stormer viscosity Imm.	Stormer Gel strength		Mud weight	
Clay	Water	NaOH				Imm.	15 Min.	Specific gravity	Pounds per gallon
20.0	80.0	0.00	0.00	6.20	2.00	1	1	1.09	9.10
20.0	80.0	0.02	2.00	7.56	2.35	1	1	1.11	9.26
20.0	80.0	0.04	4.00	8.58	3.00	3	3	1.09	9.10
20.0	80.0	0.06	6.00	8.45	5.25	1	1	1.08	9.02
20.0	80.0	0.08	8.00	8.86	6.10	1	1	1.09	9.10
20.0	80.0	0.10	10.00	9.22	17.00	1	2	1.11	9.26
20.0	80.0	0.12	12.00	9.70	23.30	5	36	1.10	9.18
20.0	80.0	0.14	14.00	10.60	40.25	31	126	1.11	9.26
15.0	85.0	0.105	14.00	8.39	4.75	3	5	1.05	8.76
15.0	85.0	0.120	16.00	8.52	12.50	6	43	1.06	8.85
15.0	85.0	0.135	18.00	9.01	17.50	46	126	1.11	9.26
12.5	87.5	0.125	18.00	8.61	8.25	4	39	1.05	8.76
12.5	87.5	0.138	20.00	9.32	17.50	18	151	1.07	8.93
10.0	90.0	0.10	20.00	11.26	7.75	6	33	1.04	8.68
10.0	90.0	0.11	22.00	11.42	7.50	8	71	1.03	8.60
10.0	90.0	0.12	24.00	11.45	11.25	61	126	1.04	8.68
10.0	90.0	0.13	26.00	11.50	19.50	66	131	1.04	8.68
10.0	90.0	0.14	28.00	11.55	23.00	76	136	1.04	8.68
10.0	90.0	0.15	30.00	11.72	21.50	66	136	1.04	8.68

POSSIBILITIES FOR UTILIZATION

The drying shrinkage of the samples classified as bond clays is too high to permit their use as the sole ingredient of a ceramic body. The utilization of the clays is necessarily confined to mixtures containing non-plastic material such as loess, sand, grog, and semi-plastic clay, and for use where their thixotropic properties are of value as in drilling mud and as a filler and suspending medium in sodium silicate glue.

The clays are contaminated with sand and silt which vary from less than one percent to 9.55 percent. This is shown in the tables of thixotropic properties. Screen analyses indicate larger percentages of residue retained on screens up through 250-mesh. This residue is largely nodules of clay-silt which do not readily break down in water alone but which disintegrate in the presence of an alkali. The ultimate grain size of the clay can not be judged by the residue shown in the regular screen analyses as no alkali was used to assist in the disintegration of the particles. The residue from the drilling mud mixtures where alkali was used is a better index to contaminating materials.

The cause of plasticity and bonding strength in a clay is not clearly understood. It is the consensus of opinion that a number of factors affect plasticity and bonding strength. In the Adams County clays 1.76 percent to 18.03 percent of soluble silica* is shown to be present. The average of 22 analyses is 8.82 percent. Although the amount of soluble silica in individual clays can not be correlated with bonding strength, it is believed that the presence of soluble silica is the contributing factor causing the abnormal dry strength of these clays. The lack of correlation between soluble silica and bond strength is accounted for by the probability that only a portion of the silica determined as soluble silica is available in the raw clay as a gel, a condition under which bonding strength was determined. The amount of soluble silica present as a gel varies with individual samples and is not necessarily present in proportion to the total soluble silica available in the presence of alkali. The disintegration of apparently non-plastic nodules of clay in the presence of alkali and the development of strong gels in the presence of alkali substantiate this theory. Should these views be correct, the addition of a small amount of alkali to these clays would increase their potency as a bond. This would be desired if the clays were used as a bond for foundry moulding

* SiO_2 soluble in 10 percent Na_2CO_3 solution.

sand where the minimum amount of bonding material is used in order to keep the sand as porous as possible. No alkali would be necessary when using the clay to bond fire clay grog for the production of saggers and crucibles, or to bond loess and semi-plastic clays for the production of heavy clay products as brick, tile, etc.

It will be noted in the table of physical properties that a number of the samples cracked on drying. The modulus of rupture values of these clays and possibly others are not representative because the test bars were not sound. Twenty-three clays that were not cracked and whose modulus of rupture values are over 1000 pounds per square inch had an average modulus of rupture value of 498 pounds per square inch when diluted with 50 percent non-plastic grog. Eighteen clays that were cracked or strained on drying gave higher modulus of rupture values after being diluted with 50 percent non-plastic grog than without grog. The average value with grog was 493 pounds per square inch. It is interesting to note that the apparently weaker clays have bonding strengths which average within 5 pounds of the stronger clays.

The fusion points or pyrometric cone equivalents of the clays were not determined as it was obvious that the clays were not of the refractory variety, although they may be used in limited amounts for low heat duty bond. They appear to be more refractory than bentonite and would likely be suitable as a bond in moulding sand. No equipment was available to determine this possibility.

When the clays, previously ground to pass a 20-mesh screen, are blunged with water alone only a portion of the particles is dispersed. This is illustrated by the low viscosity and gel strength of the mixtures shown in the table (1) of thixotropic properties. Samples G21-1 and G36-1 show promise of 10-pound per gallon drilling muds without the addition of alkali. A small but unmeasured amount of alkali was added to the mud mixture after obtaining the data in table 1. On the blunging, all of the muds became too stiff to manage. New mixtures of clay and water were made using 100 grams of clay and 400 grams of water. The mixtures were blunged for 1 hour, and to them was added 8 cc. of a NaOH solution containing 0.1 gram NaOH per cc. Blunging was continued for another hour. The results are given in table 2. Samples G14-1, G40-1, G64-1, G85-2, and G500-OC show promise as 9-pound per gallon drilling muds. All of the clays tested have excellent drilling mud possibilities.

The clay-to-water ratio and the amount of alkali necessary to develop the optimum thixotropic properties within the viscosity limits of drilling mud are variable factors with individual clays. Experimentation with each clay is necessary to determine these values. Samples G40-1 and G85-2 were subjected to further tests using several clay-to-water ratios and necessary alkali. The results given in the tables, "Properties of drilling mud from bond clays," indicate that these clays have thixotropic properties comparable to bentonite and should be investigated by commercial interests.

OCHRE

SCREEN ANALYSIS

SAMPLE G504-OC

Retained on screen	Percent	Character of residue
60	1.25	Abundance of nodules of limonitic stained silt grains; small amount of ferro-manganese material.
100	1.09	Abundance of nodules of limonitic stained silt grains; small amount of quartz and ferro-manganese.
250	3.07	Abundance of nodules of limonitic stained silt grains; small amount of quartz; trace of ferro-manganese.
Cloth	94.59	Clay substance including residue from above.

Alta Ray Gault, technician.

CHEMICAL ANALYSIS

SAMPLE G504-OC

Ignition loss	6.56	Iron oxide, Fe_2O_3	10.85	Magnesia, MgO	1.87
Silica, SiO_2	63.51	Titania, TiO_2	1.41	Manganese, MnO_2	Trace
Alumina, Al_2O_3	14.76	Lime, CaO	None	Alkalies, (K_2O, Na_2O)	0.34

B. F. Mandlebaum, analyst.

POSSIBILITIES FOR UTILIZATION

The ochre is bright yellow but is not sufficiently high in iron oxide to be classed as a commercial ore. It is relatively free from sand and other contaminating materials and is suited for use as a slip clay and pigment to enrich red burning clays.

SUMMARY

Extensive beds of clay, having unusually high bond strength, are revealed in this report. Some of the clays have normal shrinkage values and are especially suitable for use as the sole ingredient in a wide variety of red and buff burning heavy clay products. Others develop very strong gel strengths by the addition of water and small quantities of alkali, and are suitable for use as rotary drilling mud and as a bond for foundry moulding sand. Drilling muds, containing 10, 12.5, 15, and 20 percent clay, develop strong gels, having exceptional stability, and do not settle out on standing over a long period of time, but immediately break up on agitation. The muds have viscosity values well within the limits of commercial drilling mud. The clays compare favorably with commercial drilling mud clays and expensive bentonite. Ten-pound-per-gallon muds are developed with minimum alkali content, while muds of the bentonite type are developed by using ten to twenty percent clay and higher quantities of alkali. When using the minimum amount of clay, the maximum amount of alkali necessary to develop optimum gel (thixotropic) properties cost less than one dollar per ton of dry clay.

LABORATORY PROCEDURE

PREPARATION

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

FORMING OF TEST PIECES

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

PLASTIC, DRY, AND WORKING PROPERTIES

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

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

FIRED PROPERTIES

The long and short bars were burned in a down-draft surface combustion kiln especially designed for the purpose. Butane gas was used for fuel. Oxidizing conditions were maintained in the kiln during the entire period of firing. The test pieces were stacked criss-cross in the kiln to permit complete circulation of gases. The kiln was fired at the rate of 200°F. per hour to within 200°F. of the maximum temperature. The last 200°F. rise was accomplished in two to three hours. The rate of firing was measured by means of a Chromel-Alumel thermocouple up to 2100°F., at which point the couple was withdrawn from the kiln; and the firing was continued, using pyrometric cones.

CONVERSION TABLE

Cones to Temperatures

Cone No.	When fired slowly, 20°C. per hour		When fired rapidly, 150°C. per hour	
	°C	°F	°C	°F
010	890	1,634	895	1,643
09	930	1,706	930	1,706
08	945	1,733	950	1,742
07	975	1,787	990	1,814
06	1,005	1,841	1,015	1,859
05	1,030	1,886	1,040	1,904
04	1,050	1,922	1,060	1,940
03	1,080	1,976	1,115	2,039
02	1,095	2,003	1,125	2,057
01	1,110	2,030	1,145	2,039
1	1,125	2,057	1,160	2,120
2	1,135	2,075	1,165	2,129
3	1,145	2,093	1,170	2,138
4	1,165	2,129	1,190	2,174
5	1,180	2,156	1,205	2,201
6	1,190	2,174	1,230	2,246
7	1,210	2,210	1,250	2,282
8	1,225	2,237	1,260	2,300
9	1,250	2,282	1,285	2,345
10	1,260	2,300	1,305	2,381
11	1,285	2,345	1,325	2,417
12	1,310	2,390	1,335	2,435
13	1,350	2,462	1,350	2,462
14	1,390	2,534	1,400	2,552
15	1,410	2,570	1,435	2,615
16	1,450	2,642	1,465	2,669
17	1,465	2,669	1,475	2,687
18	1,485	2,705	1,490	2,714
19	1,515	2,759	1,520	2,768
20	1,520	2,768	1,530	2,786

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

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

On completing the firing of the long and short test pieces the kiln was cooled gradually in twenty-four to thirty-six hours, after which the short bars were immediately placed in descicators and weighed to an accuracy of .01 gram on a triple beam balance. After weighing, the bars were placed in water which was then heated to the boiling point and was kept boiling for four hours. They were allowed to cool in the water to room temperature and were reweighed as before mentioned. Immediately thereafter the volumes of the test pieces were determined in a mercury volumeter. Volume shrinkage, porosity, absorption, bulk specific gravity, and apparent specific gravity were calculated in accordance with methods outlined by the American Ceramic Society. The long bars were broken on a Fairbanks testing machine to determine modulus of rupture. Five long bars were burned and tested for each clay at each cone temperature indicated in the table of pyro-physical properties. Three short bars were fired as test pieces for each clay and at each cone.

SCREEN ANALYSES

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

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

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

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

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

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

THIXOTROPIC PROPERTIES

Much of the procedure used has been mentioned in the text. Viscosity and gel strength values were determined by means of a Stormer viscosimeter. pH values were determined with a laboratory model Beckman pH meter.

CHEMICAL ANALYSES

Grinding: Samples washed thru a 250-mesh screen, decanted, and dried, and then ground to a fine powder.

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

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

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

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

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

Manganese: Manganese was determined in the filtrate from the alumina determination. Manganese was precipitated as the dioxide from a buffered acetate solution by oxidation with bromine and precipitation with ammonium hydroxide. The precipitate was filtered off, ignited, and weighed as Mn_3O_4 and calculated to MnO_2.

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

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

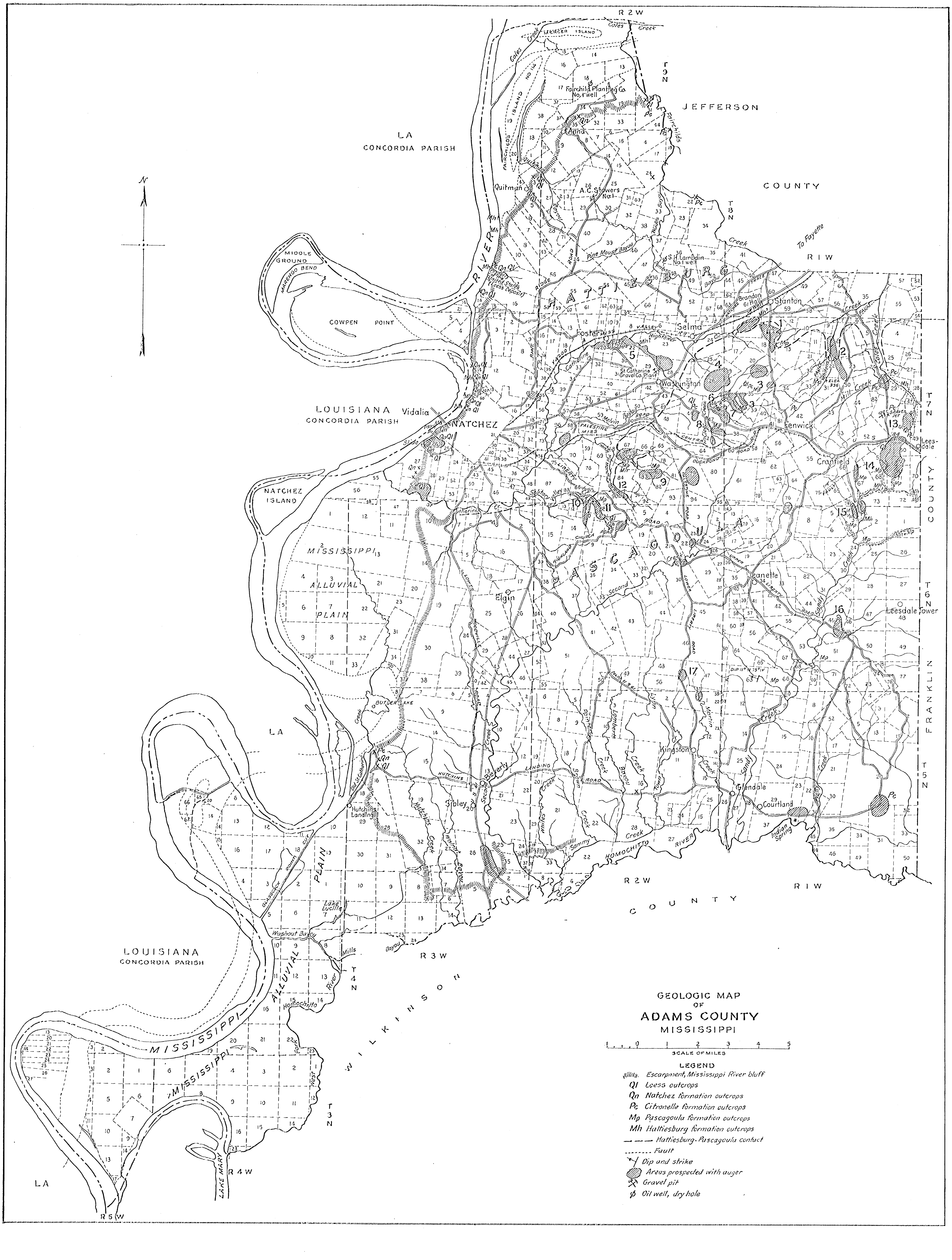
Alkalies: Alkalies were determined by the J. Lawrence Smith method as outlined in Scott "Standard Methods of Chemical Analysis." Sodium and potassium were not separated but reported as combined oxides.

Soluble Silica: A one gram sample was treated with dilute hydrochloric acid and evaporated nearly to dryness. Treated with hydrochloric acid again, heated, and filtered. The residue was heated on the water bath in a 10 percent solution of sodium carbonate for 30 minutes, filtered, and the filtrate dehydrated. The silica, now insoluble, treated as above with acid, filtered, ignited, weighed, and volatilized with hydrofluoric acid.

Duplicates were made on all samples and the average was reported.

PAGE REFERENCES TO TEST HOLES

PAGE REFERENCES TO TEST HOLES, Cont'd.


GEOLOGIC MAP
OF
ADAMS COUNTY
MISSISSIPPI
SCALE OF MILES
LEGEND
Escarpment, Mississippi River bluff
Ql Loess outcrops
Qn Natchez formation outcrops
Pc Citronelle formation outcrops
Mp Pascagoula formation outcrops
Mh Hattiesburg formation outcrops
Hattiesburg-Pascagoula contact
Fault
Dip and strike
Areas prospected with auger
Gravel pit
Oil well, dry hole
JEFFERSON
COUNTY
FRANKLIN
COUNTY
WILKINSON
COUNTY
LA
CONCORDIA PARISH
LOUISIANA
CONCORDIA PARISH
LOUISIANA
CONCORDIA PARISH
LA
LA
NATCHEZ
Vidalia
Washington
Selma
Stanton
Foster
Fenwick
Cranfield
Elgin
Kingston
Glendale
Courtland
Sibley
Quitman
Anna
Leesdale Tower
MISSISSIPPI
ALLUVIAL
PLAIN
MISSISSIPPI RIVER
NATCHEZ ISLAND
COWPEN POINT
MIDDLE GROUND
MERCER ISLAND
HOMOCHITTO RIVER
R 2 W
R 1 W
R 3 W
R 4 W
R 5 W
T 9 N
T 8 N
T 7 N
T 6 N
T 5 N
T 4 N
T 3 N