MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph.D.
Director

BULLETIN 44

FORREST COUNTY MINERAL RESOURCES

GEOLOGY

By
VELLORA MEEK FOSTER, M.Sc.

TESTS

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

UNIVERSITY, MISSISSIPPI
1941

VELLORA MEEK FOSTER

1904 - 1941

STUDENT ASSOCIATE GEOLOGIST FRIEND MAN

MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph.D.
DIRECTOR

BULLETIN 44

FORREST COUNTY MINERAL RESOURCES

GEOLOGY

By

VELLORA MEEK FOSTER, M.Sc.

TESTS

By

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

Prepared in cooperation with the Forrest citizens and the WPA as a report on O. P. 465-62-3-275.

UNIVERSITY, MISSISSIPPI
1941

LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi
October 26, 1941

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

Gentlemen:

Herewith is Bulletin 44, Forrest County Mineral Resources, 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 geologic mineral surveys of the State.

The field work by Vellora Meek Foster was completed some time ago, and the geologic part of the report was nearly finished at the time of his untimely death on September 2, 1941. Before the unfinished part, "High Terraces," "Low Terraces—Alluvium," "Sand and Gravel," and "Clay," could be written, however, it was necessary to revisit Forrest County which Mr. Glen F. Brown of the U. S. Geological Survey and the State Geologist did on October 17, 18, and 20, 1941. These parts of the report are, accordingly, by these two geologists. The field Geologic Map of Forrest County lacked some detail of the contact between the formations. This detail was kindly completed and the whole map redrawn by Dr. Louis C. Conant.

The determining of the sequence of the geologic formations of Forrest County in the first place and their delineation on the geologic map were especially difficult problems, for the reasons that the two bed rock formations, the Hattiesburg and the Pascagoula, are both clay, and, for the further reason, that all are unconsolidated, permitting thereby the mixing of the materials of the blanket Citronelle and Terrace sands and gravels. Only one contact, the Pascagoula and Citronelle, was observed, and those of the blanket formations, from the very nature of the material, are indefinite. Despite these field difficulties the report is an excellent contribution that is set forth in brief, concise, clear, pure English so characteristic of the writings of the author.

As usual, the "Tests" part of the report is by Thomas Edwin McCutcheon, B.S., Cer.Engr. and his physical and chemical technicians, Alta Ray Gault, M.S., and Malcolm Rogers Livingston, B.S.E., M.S.

As to be expected, the survey shows an abundance of clays suitable for the manufacture of brick and heavy clay products, but a clay, nevertheless, that, because of its large content of silt, presents many problems in manufacture—problems, in the solution of which, the State Geological Survey stands ready at all times to assist, as these problems arise. By means of its research facilities and personnel, the Survey also hopes to discover ways of beneficiation whereby the almost unlimited quantities of sand, now largely wasted in the production of gravel, may be utilized in the manufacture of useful products.

Like all previous county investigations, the Mineral Resources survey of Forrest County could not have been made and the results published without the aid of Federal-WPA funds and the splendid cooperation of "Major" Joseph L. Bowles (deceased), former Secretary of the Hattiesburg Chamber of Commerce, Mr. W. Tellous Wells, the present secretary, and other good citizens of Forrest County—Dr. J. B. George, President, Mississippi Southern College, and staff, Hon. Travis H. Boykin and Hon. George M. Calhoun, Former Mayor and Mayor of Hattiesburg, Herbert Gillis, H. H. Bell, and J. J. Sullivan, to mention only a few.

Very sincerely and respectfully,

William Clifford Morse,
State Geologist and Director

VELLORA MEEK FOSTER

1904 - 1941

In the passing of Vellora Meek Foster, the State lost a geologist and a man; the State Geologist, a student, an associate, and a friend — for through the years he was all of these. First he was the high school student in English of Mary Hamilton, the sweetheart, the wife, and the widow of Paul Franklin Morse, deceased son of the State Geologist. Then he was the undergraduate student, then the graduate student, and finally the colleague of the State Geologist. In English, as in geology, he was thorough as his published reports attest. His Lauderdale County Mineral Resources and Forrest County Mineral Resources, Bulletins 41 and 44 of the Mississippi State Geological Survey, stand as monuments to the conciseness of his statements and the preciseness of his expression. They likewise reveal the care of his researches, the depth of his thinking, and the clarity of his concepts — qualities that he manifested early in his undergraduate days when he analyzed technical papers and presented reports thereon worthy of much older geologists, and that he maintained throughout his professional career. Generous to a fault, he was always a friend to his friends. His parental home, his State Survey, and his State will miss his cheery smile and his generous soul.

William Clifford Morse,
State Geologist

U. S. Geological Survey
Washington, September 10, 1941.

Memorandum for the members of the Ground Water Division:

Vellora M. Foster, whom many of you met at the recent Ground Water Conference in Washington, died September 2, 1941, at his home in Starkville, Mississippi. He is survived by his mother and father.

Mr. Foster attended Mississippi State College, where he received the degree of Bachelor of Science in 1925. His graduate work was at Washington University (St. Louis) and Northwestern University. He received a degree of Master of Science at Washington University in 1927 and completed most of the requirements for a Ph.D. degree at Northwestern University in 1933. Among other positions prior to his work with the U. S. Geological Survey, he was a member of the staff at Birmingham Southern College, geologist with the Mississippi State Planning Board, and geologist with the Mississippi State Geological Survey. He became a member of the U. S. Geological Survey in January, 1940, and was assigned to ground-water work in Mississippi.

He was a member of the Alpha Chemical Society, Sigma Xi, American Society of Planning Officials, Delta Sigma Phi Fraternity, Mississippi Geological Society, and Mississippi Academy of Sciences. His application for active membership in the American Association of Petroleum Geologists was approved for publication.

Mr. Foster is the author of several geological reports, including a report on the geology and mineral resources of Lauderdale County, Mississippi, which was published as Bulletin 41 of the Mississippi Geological Survey. Prior to his illness he was preparing a report on his ground-water work in the coastal area of Mississippi.

His pleasant personality, cooperative spirit, and unselfish attitude endeared him to all who knew him. His courage was unlimited as indicated by his effort to be as helpful as possible on his official work even though he knew he could not survive his illness. His untimely death is a great loss to his friends and to the scientific world.

O. E. Meinzer,
Geologist in Charge,
Division of Ground Water.

CONTENTS

GEOLOGY

TESTS

ILLUSTRATIONS

FORREST COUNTY MINERAL RESOURCES
GEOLOGY

VELLORA MEEK FOSTER, M.S.

INTRODUCTION

GENERAL

Forrest County is located in the southeastern part of the State and is bounded by Covington and Jones Counties on the north, Perry County on the east, Stone County on the south, and Pearl River and Lamar Counties on the west (Figure 1). It is made up of 13 townships and embraces an area of 460 square miles.[1]

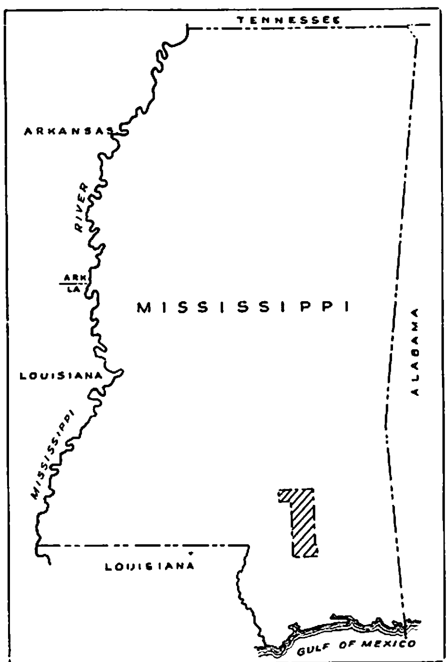

Figure 1.—Map showing location of Forrest County.

The entire county lies within the drainage area of the Leaf-Pascagoula River. The major streams all traverse the county in a southeasterly direction in strikingly parallel courses which follow approximately along the strike of the underlying formations. Named in succession, beginning with the most northeasterly, they are: Tallahala Creek, Leaf River, Bouie River, Black Creek, and Red River. The smaller streams, tributary to those named, are less regular in their courses, but in general they follow a northerly or southerly direction.

According to the 1940 census the county had a population of 34,894, of which about 63 percent were white and the remainder negro. Hattiesburg, the county seat, having a population of 21,024, is the commercial and manufacturing center of a large agricultural and lumbering area. Most of its industrial activity is based on the processing of agricultural and forestry products. There are several establishments, however, engaged in mining or manufacture of local mineral resources. Three companies mine sand and gravel from the river terraces, one makes common brick and tile from alluvial clay, and one uses local sand and gravel as an aggregate in the manufacture of cement tile.

Hattiesburg and its suburbs are supplied with natural gas from the Jackson gas field via the pipe line of a local company, and high tension electric lines of both the Mississippi Power & Light Company and the Rural Electrification Authority traverse the county.

Forrest County is served by four railroads and three paved highways all of which intersect at Hattiesburg. No part of the county, therefore, is more than six or eight miles from both railway and highway connections. In addition to the paved highways there is a network of excellent gravel roads extending to all parts of the county. The Leaf-Pascagoula River is considered navigable as far north as Hattiesburg and, although there is no longer any commercial traffic on the river, a channel can be established and maintained if the commerce of the future is sufficient to warrant periodic dredging.

TOPOGRAPHY

CUESTAS

The entire county lies within the Pine Hills physiographic region. The topography is essentially that of a maturely dissected plain sloping gently toward the southeast. Into this plain the major streams have cut broad terraced valleys separated by cuesta-shaped divides having steep northeasterly and gentle southwesterly slopes. In Forrest County cuestas are well developed between Leaf River and Black Creek and between Black Creek and Red River. The divides between Tallahala Creek and Leaf River and between Leaf and Bouie Rivers do not exhibit the typical cuesta shape and are described in connection with the stream terraces.

The crest of the divide between Leaf River and Black Creek enters the county about five miles southwest of Hattiesburg. It passes in a general southeasterly direction through the town of McLaurin and into Perry County. Although parts of the crest rise to elevations of more than 350 feet above sea level, much of the highland has been dissected by the headwaters of numerous tributary streams, and the general elevation of the crest is probably not more than 300 feet. The northward facing slope is relatively rugged and steep in character though somewhat modified by the terraces of the Leaf River. The back-slope, on the other hand, is more gentle, the streams longer, the valleys broader, and the topography more rolling. It is essentially a dip slope and toward the southwest it merges almost imperceptibly into the high terraces of Black Creek. Along parts of their courses some streams of the back-slope follow a southeasterly course and subsidiary or secondary cuestas have been developed. Thus the major watershed is in reality a composite of a complex cuesta.

The cuesta-shaped divide between Black Creek and Red River is similar to that described above, but even more complex. The main crest, which rises to an elevation of about 330 feet above sea level, enters the county north of Elder and extends in a general southeasterly direction through a point about two miles southwest of Maxie and thence to the southeastern corner of the county. The north slopes are rather abrupt in most places, but the face of the cuesta is modified by three or more prongs, or secondary cuestas, which form the divides between Black Creek and its major tributaries from the south: Little Black Creek, Big Creek, and Beaver Dam Creek. Thus the land surface appears to rise in two or more steps from the level of Black Creek to the top of the divide. The back-slopes of the secondary cuestas are in some places so gentle as to appear almost terrace-like. The back-slope of the major divide is less modified by stream erosion than is that of the cuesta between Leaf River and Black Creek and large areas are composed of very gently rolling upland. Within the limits of Forrest County the only well developed secondary cuesta on the back-slope is the divide between Double Branch and Red River which occupies an area of about nine square miles in the extreme south-western part of the county.

TERRACES

Among the most striking topographic features of Forrest County are the valleys of Bouie and Leaf Rivers and their bordering terraces. The modern valleys average respectively about two and four miles in width including the lowermost of the high terraces (elevation about 175 feet) on which Hattiesburg is built. At least two additional terraces are present at lower altitudes. Remnants of several higher terraces may also be seen in the northern part of the county.

Between Bouie and Leaf Rivers and between Leaf River and Tallahala Creek, at elevations ranging from about 200 to 290 feet, there are two fairly large areas of flat or gently rolling terraced upland (Figure 2) bordered by somewhat lower and more highly dissected areas. The cuesta shape, so characteristic of most interstream areas in the Pine Hills region, is not developed on these divides. Although they reach elevations of 125 feet or more above the floodplains these flat uplands nevertheless lie more than 75 feet below the cuesta crests to the northeast and southwest. Furthermore, the sediments on which the high plain is developed resemble lower terrace deposits rather than the gravelly sands which cap the typical cuestas in the southern half of the county. It seems evident, therefore, that the high flat divides of northern Forrest County should be considered terrace plains formed during an old erosion-deposition cycle of the associated streams.

The terraced character of the upland is best seen between the Leaf and Bouie Rivers where it is locally known as the Eatonville Flat. Along a road southeast from the town of Eatonville at least four major terraces may be seen above the first of the low terraces and including the highest level, on which Eatonville is situated. Also, the lowermost of the high terraces appears in some places to consist of three levels, separated one from the other by six-foot and eight-foot terrace scarps (Figures 3, 4, and 5B). Remnants of the several terraces are also

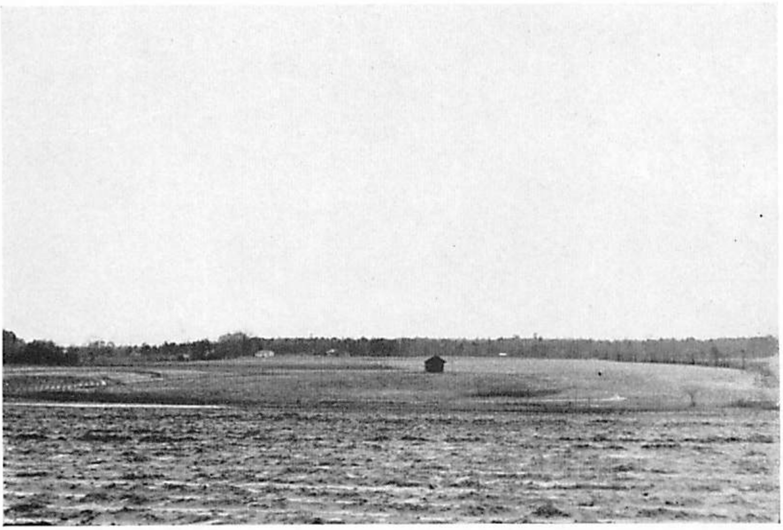

Figure 2.—High Terrace on Eatonville Flat, one mile east of Eatonville (NE.1/4, Sec. 8, T.5 N., R.13 W.). March 23, 1941.

present along other parts of the two valleys, but recent erosion has interrupted their continuity and somewhat modified their character. A proper description and correlation of the terraces, therefore, are impossible in the absence of topographic maps.

Southwest of Bouie River and extending about five miles south of Hattiesburg, there is another rather large rolling highland, some parts of which reach elevations corresponding to those of the Eatonville Flat terraces, and some parts of which are covered with terrace sand and gravel. Throughout most of that area, however, the typical silty clays of the Hattiesburg formation are at or near the surface, the elevations of which are between 200 and 250 feet, and correspond roughly with that of the clay underlying the terrace deposits north of the river. Along the outer edge of this series of terraces, thick deposits of sand and gravel, containing silt and clay in the basal part, overlap the lower part of the cuesta face.

Remnants of similar deposits are to be found along the south side of the Leaf River valley from Hattiesburg southeast into Perry County. This part of the valley wall is highly dissected and the terrace character is obscured. It is extremely difficult,

Figure 3.—High Terraces on Eatonville Flat, one mile southeast of Eatonville, showing terrace scarp between second and third terraces in right background (SW.1/4, SE.1/4, Sec. 8, T.5 N., R.13 W.). March 23, 1941.

Figure 4.—Terrace scarp between Second and Third High Terraces, 0.7 mile southeast of Eatonville (SE.1/4, SW.1/4, Sec. 8, T.5 N., R.13 W.). March 23, 1941.

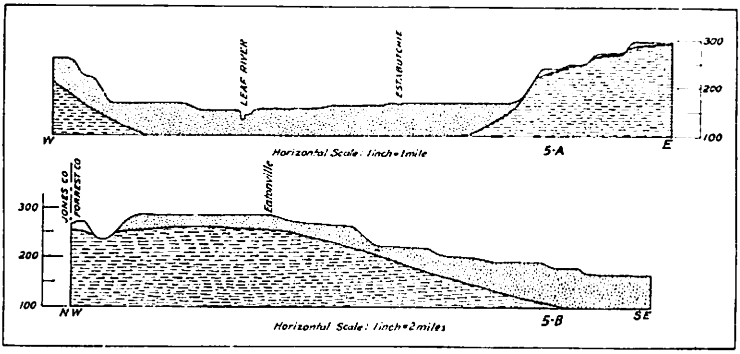

Figure 5.—Profile sections of Leaf River Valley
A. East-west section along Forrest-Jones County line.
B. Northwest-southeast section through Eatonville.

therefore, to distinguish between high terrace deposits and reworked sediments of the Citronelle formation which may have collected on the slopes as colluvium in recent times. The crests of many of the hills, however, correspond in general with the elevations of the high terraces described above, and the sediments more nearly resemble those of the high terraces than those of the Citronelle formation where the latter is undisturbed. It is believed, therefore, that most of the sand and gravel deposits which lie at elevation of less than 280 or 300 feet are remnants of former high terraces or more recent colluvium.

No attempt is made in this report to describe the terrace deposits along the other streams of the county. It is known, however, that both high and low terraces are present along Black Creek, Red River, and a few smaller streams. They closely resemble those of the Leaf and Bouie Rivers, though neither is as extensive nor as well preserved as those bordering the larger streams. Wherever the terraces were seen in the course of the present survey they are shown on the accompanying map. (Plate 1)

STRATIGRAPHIC AND AREAL GEOLOGY

GENERAL

The bedrock of Forrest County consists of a great thickness of massive blue clay, silt, and clayey fine-grained sand of Miocene age, and red gravelly sand probably Pliocene in age. The bedding is indistinct and the lithology remarkably uniform. No key beds or fossiliferous zones are known. 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. The only stratigraphic marker noted, therefore, is the unconformable contact between the Miocene clays and silts and the Pliocene sand.

Outcrops of the Miocene formations are most common on the lower slopes of the cuestas and in the deep narrow valleys which dissect the crests. The Pliocene sand crops out near the crest of the Leaf River-Black Creek divide and along the backslope of the cuesta between Black Creek and Red River. Colluvium derived from the Pliocene and High Terrace sand extends down the slope in many places, masking the outcrops of the underlying clay.

As previously mentioned high terrace deposits of the larger streams cover the lower cuesta slopes in many places and almost completely cover the bedrock geology over large areas in the northern third of the county. Furthermore, because of the ease with which sands of the Pliocene and High Terrace deposits are eroded, the valley floors of the streams, both large and small, are commonly buried under a considerable thickness of river alluvium and low terrace deposits. For these reasons, good exposures of Miocene clay and silt are rare and of limited extent. The absence of extensive outcrops and the uniform lithology of the formations render a stratigraphic study difficult. In the descriptions which follow, therefore, considerable reliance is placed on test holes and well logs, representative examples of which are cited.

MIOCENE SYSTEM

CLASSIFICATION

That part of Mississippi's geologic section now considered to be of Miocene age was first described in 1854 by B. L. C.

Wailes.[2] In his report on the agriculture and geology of Mississippi he described certain prominent ledges of sandstone which, together with associated sandy clay and siltstone, crop out in the bluffs of the Mississippi River in the vicinity of Fort Adams, Wilkinson County, and near Grand Gulf, Claiborne County. To the former he applied the name "Davion Rock," and to the latter, "Grand Gulf Sandstone." He apparently believed the rocks in the two areas of outcrop to be of the same age and traced them up the Homochitto River and its tributaries into central Franklin County and up the Big Black River and Bayou Pierre to the vicinity of Clinton and Raymond in Hinds County. Dr. Wailes did not assign an age designation to these rocks, but from his description it appears that he recognized their stratigraphic position above the limestones at Vicksburg and Jackson (now known to be Oligocene in age) and below the "Orange Sand" (Citronelle).

Dr. L. Harper in 1857[3] did not describe the rocks included in the outcrop area of "The Grand Gulf Sandstone," but erroneously considered the "Lignitic" (Eocene) and the "Orange Sand" (Eocene, Pliocene, and Pleistocene?) to be Miocene in age. The geologic map, which accompanied the report, shows rocks of Eocene age in all that part of the State now known to be underlain by younger sediments. From Dr. Harper's description of the limestones and marls of central Mississippi (Jackson and Vicksburg formations of more recent reports) it appears that he believed them to be continuous southward to the vicinity of the coast.[4]

In 1860 Dr. Eugene W. Hilgard[5] proposed the name Grand Gulf Group for the series of sandstone and sandy clay which crop out in the vicinity of Grand Gulf and Fort Adams. He traced these beds, and described numerous outcrops showing the lithologic character and stratigraphic relations as far eastward as the Chickasawhay and Pascagoula Rivers. Hilgard recognized the age equivalency, and hence the lateral gradation lithologically, of the Grand Gulf sediments at the type locality and the more clayey less consolidated sediments farther east. He also described a change in lithology from north to south. Throughout the outcrop area, his descriptions show the more northerly outcrops to consist of alternating sand or sandstone and sandy clay or siltstone, succeeded toward the south by more massive blue and gray clays, and finally, in the most southerly outcrops, by alternating layers of greenish-gray and light-gray sand or siltstone and sandy clay. Furthermore, the gentle southerly and southwesterly dips are described at a number of localities, and presumably he recognized that the more southerly outcrops were the younger. It is precisely these lithologic differences which were used by later geologists in making the threefold division of the Miocene which is followed in present day usage. Inasmuch as the only fossils found were lignitized plant remains and poorly preserved leaf prints, Hilgard did not definitely specify the age of the sediments except as being post Vicksburg and pre-Pleistocene. He suggested, however, that on the basis of the available data they might logically be considered Eocene in age.[6] Later work led him, in 1881, to suggest the Miocene age of the Grand Gulf Group.[7]

Prior to the work of L. C. Johnson in 1888 all attempts at establishing the age of the Grand Gulf were based entirely on its supposed stratigraphic relations. No fossils, other than a few poorly preserved *Unios* and plant remains of a non-diagnostic character, had been discovered in the sediments of the Grand Gulf. Furthermore, good exposures of the formation were so uncommon, and the contacts so obscured by superficial sediments, that there were those who questioned the stratigraphic relationships described by Hilgard and others. On the basis of a detailed study of stratigraphic relations in Louisiana, Mississippi, and Alabama, Johnson, in 1889, definitely established the age of the Grand Gulf as "not older than Miocene" and "as certainly not Quaternary."[8]

Johnson also discovered Miocene fossils in the section of the Grand Gulf along the lower Chickasawhay and Pascagoula Rivers. He considered these fossiliferous beds as the equivalent of the upper part or the whole of the Grand Gulf in other parts of the State and proposed that, pending the determination of their precise relation, they be called the Pascagoula formation.[9] In 1893 Johnson described the Grand Gulf sediments of Mississippi and Alabama in more detail[10] and traced them into fossiliferous beds in eastern Alabama and adjacent parts of Florida and Georgia. He proposed that in eastern Mississippi the Grand Gulf be divided, in ascending order, into the Ellisville phase, the Hattiesburg phase or formation, and the Pascagoula phase or formation. The division was made on the basis of the lithology, and boundaries described by Johnson do not everywhere include exact age equivalents. In eastern Mississippi, however, they correspond approximately with the contacts of the three Miocene formations as recognized by later authors.

Following the work of Johnson, and coincident with a study of the fossiliferous beds with which he and others had correlated the Grand Gulf, the age of these beds came into question. Dall,[11] Maury,[12] Harris,[13 14] and others considered the lower part of the section, that part lying uncomformably below the Pascagoula, to be Oligocene in age. Smith,[15] and others of the Alabama Survey, erroneously correlated the mottled clays and sands, they found overlying the Pascagoula fossiliferous beds in southern Alabama, with the "typical Grand Gulf" of Mississippi. This they considered as proof that the "Grand Gulf" was a blanket formation younger than the Pascagoula but older than the "Lafayette," and, therefore, Pliocene in age. Subsequently the name "Grand Gulf" was used with various shades of meaning by a number of authors.

Because of the confusion which existed in the use of the name to designate sediments ranging in age from Eocene in western Texas[16] to Pliocene or later in southern Alabama,[15] Veach,[17] in 1906, proposed the name Catahoula formation to replace the "typical Grand Gulf" of Dall and the "Grand Gulf proper" of Harris. The name was taken from the numerous good outcrops of the formation in Catahoula Parish, Louisiana, and special reference was made to an early description which antedated the naming of the Grand Gulf by Wailes.[2]

The term Grand Gulf Group was revived in 1940 by the Mississippi Geological Society[19] and is now used by commercial geologists of the State in much the same sense as originally defined by Hilgard. The validity of the threefold division of the Group as proposed by Johnson, Matson, and others was recognized and, in addition, certain fossiliferous beds of questionable age, lying between the Vicksburg limestone and the Catahoula sands and clays, were tentatively included with the other formations of the Grand Gulf Group. The correlation chart illustrates the changing classification of these strata and the modern usage and correlation of the Miocene formation of Mississippi.

CATAHOULA FORMATION

The Catahoula formation is not exposed at the surface in Forrest County but is reached by numerous wells at depths of 300 to 400 feet in the valleys of the Leaf and Bouie Rivers.

HATTIESBURG FORMATION

At Hattiesburg, the Hattiesburg formation, as exposed in the river bluffs, consists of thick beds of massive clays—150 or 200 feet thick—which contain some lime but very little sand. Wells in the vicinity of Hattiesburg and outcrops in the extreme northeastern corner of the county—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. Outcrops along the higher parts of the river bluffs at Hattiesburg and wells at Camp Shelby show that the thick clay bed is overlain by and grades upward into alternating fine-grained silty sands and clays similar to outcrops of the Pascagoula farther south. In some places this upper sand-clay zone—40 or 50 feet thick—is partly consolidated to a soft sandstone. This interval has usually been considered the uppermost member of the Hattiesburg formation and has been so mapped in the past. That is also the present conception of the oil geologists who have worked in the territory. The burning tests in the laboratory, however, show that the pyro-physical properties of this upper interval more closely resemble the burning properties of the known Pascagoula than of the underlying thick clay. Accordingly, one would be inclined to draw the Hattiesburg-Pascagoula contact at the top of the massive clay bed. However, in the absence of definite proof, it can only be stated that the contact between the two Miocene formations—the Hattiesburg and the Pascagoula—is either covered or gradational and so obscure that it cannot be definitely located.

PASCAGOULA FORMATION

Along the Pascagoula River, the type locality of the Pascagoula formation, an unconformity between the Hattiesburg formation and the overlying Pascagoula formation is supposed to be present. A search along the Pascagoula River from Pascagoula to Merrill and along the Leaf River from Hattiesburg to Beaumont failed to locate an unconformity. Although the out-

Correlation Chart

Wailes, 1854 Mississippi	Harper, 1857 Mississippi	Hilgard, 1881 Mississippi	Johnson, 1893 East Miss.	Dall, 1898 Gulf Coast	Smith, 1902 Alabama	Veach, 1906 Louisiana	Deussen, 1914 Texas	Matson, 1916 Gulf Coast	Miss. Geol. Society 1940	Foster, 1941 Forrest County Miss.	U. S. Geological Survey Correlation Chart Eastern Ala., 1935
Diluvium	Post-Plio.: Alluvium Loess	Pleistocene: Brown-loam Bluff	Pleis.: Terraces	Pleis.: Columbia	Pleis.:	Pleis.: Port Hudson	Pleis.: Lissie	Pleis.: Coastal terraces	Pleis.: Coastal terraces	Pleis.?: High terraces	Pleis.: Terrace deposits
	Mio.: Orange Sand group	Pleistocene: Orange sand	Plio.: Lafayette	Plio.: Lafayette	Plio.: Lafayette Grand Gulf	Plio.: Lafayette	Plio.: Uvalde	Plio.: Citronelle formation	Plio.: Citronelle	Plio.: Citronelle formation	Plio.: Citronelle form.
Davion Rock	Eocene: Vicksburg and Jackson Marls	Miocene ?: Grand Gulf group	Miocene, Grand Gulf group: Pascagoula formation	Miocene: Oakville beds Pascagoula Chesapeake	Miocene: Pascagoula in Mississippi and western Alabama correlated with marine beds in Florida and Georgia	Mio.: Pascagoula	Miocene: Dewitt Fleming	Mio.: Pascagoula clay	Miocene, Grand Gulf group: Pascagoula	Miocene: Pascagoula formation	Miocene: Choctawhatchee formation
Grand Gulf sandstone			Hattiesburg formation	Oligocene, Trans.: Alum Bluff beds Oak Grove sand Chipolan: Tampa beds Chipola beds Upper Chattahoochee Altamaha grits		Oligocene: Fleming clay	Oligocene: Catahoula sandstone	Oligocene: Hattiesburg clay	Hattiesburg	Hattiesburg formation	Alum Bluff: Chipola formation
			Ellisville phase	Lower Chattahoochee Typical Grand Gulf Hawthorn beds		Catahoula formation		Catahoula sandstone	Catahoula Chickasawhay Bucatunna	Catahoula formation ? ? ? ?	Mio. ?: Tampa limestone
Eocene: Vicksburg beds		Eocene: Vicksburg	Oligocene: Vicksburg	Trans.: Shell Bluff group (?) Vicksburgian: Ocala group Coral limestone Vicksburg Red Bluff	Oligocene: Vicksburg	Vicksburg formation	Vicksburg	Vicksburg limestone	Oligocene, Vicksburg: Byram marl Glendon ls. Marianna ls. Forest Hill Red Bluff	Oligocene	Oligocene: Vicksburg group
Jackson beds		Jackson	Eocene: Jackson	Eocene, Jacksonian: Zeuglodon beds Moodys Branch beds Marks Mill beds	Eocene: Jackson	Eocene: Jackson	Eocene: Jackson	Eocene: Jackson formation	Eocene, Jackson group: Yazoo clay Moodys marl	Eocene	Eocene: Ocala limestone
	Miocene: Lignitic group										

crops are few and usually obscured by terrace deposits, all consist from top to bottom of interbedded fine-grained silty sands, silts, and sandy clays similar to the outcrops of the Pascagoula near Brooklyn in Forrest County. In contrast to the typical Hattiesburg clay, which is blue at or near the surface and light chocolate in the deeper test holes, the Pascagoula clay is more nearly sky blue and commonly has a somewhat greenish tint. Furthermore, the clays of the Pascagoula are more sandy, and sand beds several feet in thickness are not uncommon.

PLIOCENE SYSTEM

CLASSIFICATION

Because of the confusion in the use of all prior names, Matson in 1916, proposed the name Citronelle formation for those beds of sand, gravel, and clay which disconformably overlie the Miocene sediments of southern Alabama and Mississippi and are in turn disconformably overlain by the coastal terrace deposits. The name was derived from typical exposures in the vicinity of Citronelle, Mobile County, Alabama.

CITRONELLE (?) FORMATION

In Forrest County most of the material formerly mapped as Citronelle is, in reality, River Terrace. Possibly the entire formation, with the exception of one or two outcrops, could logically be referred to terrace deposits—as in Louisiana where the name Citronelle has been abandoned. In Forrest County, one or two outcrops of interbedded sand and clay unconformably overlie the Pascagoula and seemingly have the same regional dip as the lower formation. In appearance these outcrops are the same as those described near the type locality of the Citronelle formation. On the geologic map of Forrest County, the Citronelle is shown as capping the highest parts of the cuestas. From the character of the sediments, however, and the stratigraphic relations of these sediments, they could just as logically be considered high terrace deposits.

PLIOCENE (?) OR PLEISTOCENE (?) SYSTEM

HIGH TERRACES

As stated under the heading of "Topography" where the physiographic expression of the High Terraces was described in some detail, these high terraces may be seen best between the Bouie and Leaf Rivers where the uppermost is known as the

Eatonville flat. Along a road extending through the Village of Eatonville southeastward toward the Leaf, four major terraces including the Eatonville plain are visible above the first of the Low Terraces—and the lowest of the four major terraces consists in places of three levels, separated the one from the other by six-foot and eight-foot terrace scarps (Figure 5B). Although the underlying Hattiesburg clay was not seen on October 18, 1941, yet there is no doubt of the correctness of this Eatonville cross section by Foster, for the reason that the underlying Hattiesburg clay is well exposed beneath the terrace material along the Forrest-Jones County line section (Figure 5A), and because of spring water that pours out beneath the sand into Providence Branch near the northwestern end of the Eatonville cross section.

Material of the Eatonville terrace near the Jones County line consists in descending order of soil, subsoil, weathered sand, and fresh sand associated with which is a small amount of fine gravel—all surficial. Both the sand and the gravel are somewhat cross-bedded and otherwise irregularly bedded. Material of the second terrace consists likewise of soil, subsoil, weathered sand, fresh sand and a very small quantity of fine gravel. Both the sand and the gravel are likewise cross-bedded. Materials of each of the succeeding major terraces and minor terraces consist, so far as determinable at the surface, of soil and weathered sand subsoil.

RECENT SYSTEM

LOW TERRACES—ALLUVIUM

It may not be possible to differentiate the materials of the lower of the low terraces or even of the upper of the low terraces from the alluvium on topographic evidence, for the reason that in extreme high waters all may be flooded. Accordingly, they are, in reality, not materials of terraces but of higher bottoms of the flood plain still subjected to coverage. Perhaps it is well, therefore, to consider the material of all of them as alluvium. As alluvium, it consists of the ordinary flood plain sand and gravel, and silts and clays. Between the Bouie and the Leaf, the sands and gravels have been deposited in great thicknesses. If to the 18.5 feet of sand and gravel above the present low water (stream level) in the gravel pits be added some 40 to 60 feet of sand, gravel, and clay that are being pumped from beneath the pit water, the total thickness is 60 to 80 feet of sand and gravel.

ECONOMIC GEOLOGY

STRUCTURE

The Miocene and Pliocene sediments dip gently toward the south or slightly west of south at the average rate of not more than 15 or 20 feet to the mile. Because of inadequacy of exposures and the lack of Key Beds, it is difficult to determine accurately the dip in any exposure or to correlate the beds from one exposure to another, so that calculations of local dip may be made. The average figure of 15 feet to the mile, therefore, is based on the work of many preceding geologists in the field and on attempted correlation of major units in widely separated wells.

In only one locality within the county was surface evidence of a local structure noted. In a cut on Highway U. S. 49 (NE. 1/4, SE. 1/4, Sec. 16, T. 1 S., R. 12 W.), 1.3 miles south of Maxie (Figure 6), the disconformable contact between the Pascagoula clay and the overlying Citronelle formation is well exposed. The contact dip is abnormally steep toward the south—approximately 3 degrees. The basal Citronelle at this locality is composed of alternating beds of fine sand and sandy clay which

Figure 6.—Pascagoula-Citronelle contact in road cut on Highway U. S. 49, 1.3 miles south of Maxie, showing abnormally steep dip. 1940.

may be a reworked part of the underlying Pascagoula. These individual beds, which are approximately a foot in thickness, are uniform throughout the extent of the outcrop and extend parallel to the disconformity at the base. Within a radius of 2 miles are several other outcrops of indistinctly bedded sandy clay and silt, which seemingly show an abnormally steep dip to the south. In no other outcrop, however, is the unconformity exposed; and, therefore, it was impossible to distinguish between true dip and possible cross bedding.

OIL AND GAS

According to rumor, a favorable structure was found in the vicinity of Maxie, but lack of surface exposures makes the verification of this rumor impossible by surface methods. Subsequent to the field work of the present survey, however, geophysical prospecting and drilling by Fohs has apparently confirmed the presence of such a structure. It is believed to be a minor feature, related to the Wiggins high in Stone County—also determined by geophysical methods and drilling.

SAND AND GRAVEL

Forrest County in general and Hattiesburg in particular are supplied with an abundance of gravel and sand suitable for many uses. The older Citronelle deposits largely blanket the higher interstream areas, whereas the younger richer, Low Terrace and Alluvium, deposits are confined to the valley areas. Of the two types of deposits the alluvium is by far the richer in gravel.

Although the low terrace-alluvium deposits were formerly worked along the Bouie River near the Covington County line and along the Leaf River some two and three miles south of Hattiesburg, production today is confined to the Bouie-Leaf interstream area across the Bouie bridge from Hattiesburg. Here on adjoining properties are located the two producing corporations.

The nature of the deposits can perhaps best be described in the following section which was measured at the westernmost point of development of the two operating properties, and hence farthest upstream.

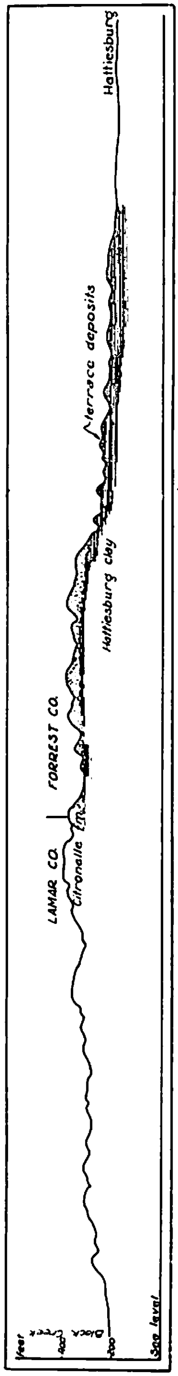

Figure 7.—Cross section along Highway U. S. 11 from Hattiesburg to Black Creek.

SECTION AT THE WEST END OF THE AMERICAN SAND AND GRAVEL COMPANY PIT, HATTIESBURG

	Feet
Level of Low Terrace or valley flat (flood plain)	....
Sand containing a few pebbles; grades upward into weathered yellow sandy subsoil	3.0
Sand and gravel alternating in cross beds, the sand constituting perhaps 70 percent of the total amount—the Superintendent estimated 80 percent	8.5
Gravel that stands in vertical walls just above the pit water level. Most of the pebbles are less than 1 inch; a few are 3 inches. A few cross beds of coarse clear quartz sand, which constitutes about 40 percent of the whole	7.0
Water level in the pit	....
Gravel, which, according to the Superintendent, is about the same as that directly above the water, extends to a depth of	40.0
Clay and sand, mostly, in the western part of the pit; gravel and clay, mostly, in the eastern part (Supt.)	20.0

The intervals of the section of the pit thus total nearly 80.0 feet of sand and gravel. Inasmuch as the flat in the eastern adjoining Forrest County Gravel Company pit, is some 5 to 7 feet higher, the total thickness of the sand and gravel reaches a maximum of something like 85.0 feet.

Inasmuch as the American Sand and Gravel Company recover the sand and gravel by means of a centrifugal gravel pump, the product, of necessity, has to be washed sand and washed gravel. Most of the gravel (1 1/2-inch to 1/4-inch) is produced for concrete; some of the gravel (1/4-inch to 16 mesh) is used in lining gravel.wall water wells. The sand is commonly produced in three sizes: 1/4-inch to 200-mesh, 1/8-inch to 200-mesh, and 16-mesh to 200-mesh. Its common use is for fine aggregate for concrete and for masonry purposes. The plant capacity is 25 50-ton cars of gravel in 12 hours. The reserve is 40 acres.

The Forrest County Gravel Company (the Louisiana Sand and Gravel Company until 1928) likewise produces exclusively washed sand and washed gravel from the adjoining eastern pit. Much of the gravel product (1 1/2-inch to 1/4-inch) is used for coarse aggregate in concrete highway construction; its sand product is produced in different sizes from 1/4-inch downward. The daily capacity of the plant is 20 50-ton cars of gravel and 10 50-ton cars of sand. The reserve is 40 acres.

Both the American Sand and Gravel Company and the Forrest County Gravel Company are located on the New Orleans and North Eastern Railroad within the switching limits of Hattiesburg, which thus provides them with shipping facilities via the Bonhomie & Hattiesburg Southern, the Mississippi Central, and the Gulf and Ship Island, railroad systems.

Not only are great quantities of washed sand being sluiced back into the pits as waste material, but such has been the practice in the past at all the former pits. Foster estimated 1,500,000 to 2,000,000 cubic yards of washed sand in the pits south of Hattiesburg; 1,000,000 to 1,500,000 cubic yards, in the Bouie River pits at the Covington County line; and 3,500,000 to 4,000,000 cubic yards, in the past and present workings north of Hattiesburg. This sand is available for colored glass and, by treating, may be suitable for higher quality glass ware.

Preliminary analyses of samples of this waste sand, which Foster submitted, show the following average chemical composition:

Ignition loss	0.24
Silica—SiO_2	96.24
Alumina—Al_2O_3	1.42
Iron Oxide—Fe_2O_3	0.11
Titania—TiO_2	0.10
Undetermined	1.89
Total based on dry weight	100.00

It is the small quantity of titania, TiO_2, and iron oxide, Fe_2O_3, averaging 0.21 percent, that the State Geological Survey laboratories are still hopeful of discovering a means of economically eliminating.

The second type of deposit, the high interstream area deposit, is the source of road metal and construction material some 10 miles south of Hattiesburg. Within the limits of Camp Shelby reservation, the U. S. Army opened a number of small sand and gravel pits in the Citronelle formation for its own use in which the gravel probably did not exceed 10 percent of the whole. Approximately 1.5 miles north of the west entrance to the camp near U. S. Highway 49, the Army is now producing, with a small power shovel, sand and gravel.

On the Weldy property near the eastern edge of the military reservation, Mr. Jack Harris is producing sand and gravel from the Citronelle formation at the top of the western bluff of the Leaf River Valley.

SECTION OF THE WELDY PIT IN THE LEAF RIVER BLUFFS, 2 MILES SOUTH OF McCALLUM AND 10 MILES SOUTH OF HATTIESBURG

	Feet
Top of the bluff	....
Sand overburden. Approximately	5.0
Gravel and sand slightly stratified, both white and yellow. The gravel constitutes about 40 percent. Approximately	25.0
Sand, fine to coarse, cross-bedded and water laid	30.0

The gravel is won by means of a dragline, is hauled in trucks to the washer on the side of the bluffs, is washed, and is then hauled in trucks back up the bluffs to camp construction projects for concrete. Spring water from the base of the bluffs is used for washing. The plant has been established, no doubt, to meet the temporary needs of camp construction.

Citronelle sand and gravel, as previously stated, form the cap of many of the higher interstream areas in Forrest County. The proportion of gravel is by no means constant, but a sufficient quantity for local use is present at many localities.

CLAY

At the present time the Hattiesburg Brick Works is the only industry utilizing clays in Forrest County. From the Hattiesburg clay and possibly from it and some of the adjacent alluvium, the plant produces red to brown common brick and textured face brick. Its capacity is approximately 400,000-brick a month.

The clays of Forrest County, belonging to the Hattiesburg and the Pascagoula formations and perhaps to other formations, are abundant wherever exposed, especially northwest and southwest of Hattiesburg where most of the samples were collected. In addition to the present brick usage, the clays are suitable for the manufacture of a wide variety of heavy clay products, as described in the test part of the report. By further utilization of the clays at hand, the industry could be expanded to include the manufacture of many products now being shipped into the county and into the State.

TEST HOLE RECORDS

A total of 191 test holes were drilled within the limits of Forrest County. A part of these were drilled to assist in a study of the stratigraphic relations and areal distribution of the several geologic formations, a part were drilled in order to discover deposits of possible economic value, and a part were drilled to determine the extent of known deposits. It was not thought to be worthwhile to reproduce the records (logs) of all test holes drilled, as many encountered nothing of economic value and others served only to confirm the presence and lateral extent of beds encountered and sampled in other holes. In the several pages which follow there are reproduced the records (logs) of all test holes from which samples were tested in the laboratory. In addition there are included records of other representative test holes from virtually every part of the county. These records serve to illustrate the stratigraphic and economic geology of the county and reference is made to them by number in both the Geology and Tests sections of the report. The records (logs) of all test holes drilled within the county may be consulted in the files of the Mississippi Geological Survey at University, Mississippi.

The ceramic tests do not show significant differences in the pyrophysical characteristics of the several formations, and no attempt is made, therefore, to group the test hole records (logs) according to formations, or according to the ceramic qualities of the samples collected. Rather, the records are numbered consecutively in the order in which the test holes were drilled. The test hole numbers and sample numbers constitute a cross index between the several parts of the report.

Hattiesburg Brick Works Property

Test Hole 1

Location: T.5 N., R.13 W., Sec. 32, SW.1/4, SW.1/4; 250 feet east of the east side of Hattiesburg Water Works Pumping Station

Drilled: October 9, 1939

Elevation: 239 feet Water level: 30.5 feet

No.	Depth	Thick.	Description of strata
			High Terrace (?)
1	1.0	1.0	Sand, coarse grained
			Hattiesburg formation
2	3.1	2.1	Sand, reddish brown semi-plastic medium grained clayey; C-1
3	7.3	4.2	Clay, variegated red, gray, and yellow, plastic sandy, slightly carbonaceous; P-1
4	19.5	12.2	Clay, brownish gray semi-plastic sandy, slightly carbonaceous; P-2
5	33.0	13.5	Clay, dark gray semi-plastic sandy, carbonaceous, slightly limey, very silty; C-2
6	40.5	7.5	Clay, light gray and yellow semi-plastic silty, carbonaceous; C-3

Hattiesburg Brick Works Property

Test Hole 1A

Location: T.5 N., R.13 W., Sec. 32, SW.1/4, SW.1/4; 250 feet east of the east side of Hattiesburg Water Works Pumping Station

Drilled: October 9, 1939

Elevation: 239 feet Water level: 30.5 feet

No.	Depth	Thick.	Description of strata
			High Terrace (?)
1	1.0	1.0	Sand, brownish gray
			Hattiesburg formation
2	3.7	2.7	Sand, reddish brown semi-plastic clayey
3	50.6	46.9	Clay, light gray sandy, slightly micaceous, slightly limey; mottled with red and yellow limonite stains; P-1

Hattiesburg Brick Works Property

Test Hole 2A

Location: T.5 N., R.13 W., Sec. 32, NW.1/4, SW.1/4; 350 feet north and 40 feet east of the northeast corner of the Hattiesburg Water Works Pumping Station Drilled: October 5, 1939

Elevation: 204 feet Water level: 40.5 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	1.6	1.6	Clay, light brown and gray plastic silty
2	13.9	12.3	Silt, light gray semi-plastic clayey, slightly micaceous, slightly carbonaceous; C-1
3	59.1	45.2	Clay, light gray silty, micaceous; P-1

Remarks: Intervals 1 and 2 correspond to the lower part of interval 3 in Test Hole 1A.

Hattiesburg Brick Works Property

Test Hole 3

Location: T.5 N., R.13 W., Sec. 32, NW.1/4, SW.1/4; 125 feet north of Test Hole 2A Drilled: March 15, 1939

Elevation: 156 feet Water level: 12.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	36.0	36.0	Clay, light gray to dark bluish gray plastic silty, limonitic, slightly limey; P-1
2	47.5	11.5	Clay, dark bluish gray plastic silty, carbonaceous; interbedded with white limey clay; P-2
3	66.0	18.5	Clay, same as interval 2; P-3
4	67.8	1.8	Sand, light bluish gray fine grained semi-plastic clayey; slightly micaceous

Remarks: Sample F-3A-P-1 is a composite sample of intervals 1, 2, and 3.

A. R. Sumrall Property

Test Hole 5

Location: T.5 N., R.13 W., Sec. 31, NW.1/4, SE.1/4; 75 feet east of residence

Drilled: October 17, 1939

Elevation: 267 feet — Water level: 20.1 feet

No.	Depth	Thick.	Description of strata
			High Terrace
1	1.3	1.3	Topsoil
2	24.0	22.7	Sand, variegated red, brown, and yellow, fine grained lignite; C-1
			Hattiesburg formation
3	43.0	19.0	Clay, gray plastic sandy, carbonaceous; upper part stained with limonite; 5A-P-1
4	60.5	17.5	Clay, same as interval 3

Remarks: Sample F-5-P-1 is a composite sample of intervals 3 and 4.

Mrs. J. T. Burch Property

Test Hole 6

Location: T.5 N., R.14 W., Sec. 25, SW.1/4, SE.1/4; 450 feet southeast of highway crossing and 30 feet east of the center line of the road

Drilled: March 17, 1939

Elevation: 225 feet — Water level: 54.0 feet

No.	Depth	Thick.	Description of strata
			High Terrace (?)
1	3.1	3.1	Topsoil
2	4.2	1.1	Sand, variegated light gray, orange, and red, clayey; C-1
3	12.3	8.1	Clay, light gray and brown semi-plastic; P-1
4	77.2	64.9	Sand and silt, fine grained clayey, micaceous

Mississippi Southern College Property

Test Hole 7

Location: T.4 N., R.13 W., Sec. 7, NW.1/4, NW.1/4; 500 feet northwest of bridge crossing the Mississippi Central Railroad and 70 feet south of the railroad Drilled: March 22, 1939

Elevation: 247 feet Water level: 24.4 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation (?)
1	0.5	0.5	Topsoil
2	7.0	6.5	Clay, reddish brown and gray sandy; contains scattered small chert gravels embedded in clay; C-1
3	55.5	48.5	Clay, light gray slightly sandy, carbonaceous slightly limey; contains a few scattered quartz and chert pebbles as large as 0.5 inches in diameter; P-1

A. R. Sumrall Property

Test Hole 8

Location: T.5 N., R.13 W., Sec. 31, NE.1/4, SW.1/4; 175 feet southeast of Mixon Creek bridge and 30 feet west of Highway U. S. 49 center line Drilled: October 11, 1939

Elevation: 211 feet Water level: 50.5 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation (?)
1	0.2	0.2	Topsoil
2	2.7	2.5	Clay, gray-brown plastic slightly sandy, slightly carbonaceous; C-1
3	50.8	48.1	Silt, light gray plastic clayey; limey carbonaceous; P-1
4	51.8	1.0	Sand, light bluish gray coarse grained

Markie E. Stevens Property

Test Hole 12A

Location: T.4 N., R.13 W., Sec. 6, NW.1/4, NE.1/4; 0.4 mile south of Highway U. S. 49 and 80 feet east of center line of north-south road

Drilled: October 16, 1939

Elevation: 215 feet Water level: 28.2 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.8	0.8	Topsoil
2	43.6	42.8	Clay, light gray carbonaceous, limey, silty, micaceous; stained with limonite; P-1

J. J. Newman Lumber Co. Property

Test Hole 14A

Location: T.5 N., R.14 W., Sec. 27, NW.1/4, NE.1/4; 0.4 mile west of road junction at section corner and 30 feet south of section line

Drilled: October 12, 1939

Elevation: 238 feet Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation (?)
1	0.7	0.7	Topsoil
2	4.8	4.1	Sand, light brown and gray very fine grained; contains pea-gravel
3	44.8	40.0	Clay, light gray to light brown plastic sandy, carbonaceous; contains scattered pea-gravel; P-1

McCaughey and Calhoun Property

Test Hole 20

Location: T.5 N., R.14 W., Sec. 11, SE.1/4, SE.1/4; 0.95 mile north of Bouie River bridge and 50 feet west of road Drilled: April 17, 1939

Elevation: 240 feet Water level: 19.3 feet

No.	Depth	Thick.	Description of strata
			Low Terrace (?)
1	0.7	0.7	Topsoil
2	5.0	4.3	Clay, dark reddish brown sandy; contains scattered pea-gravel; C-1
3	13.0	8.0	Sand, reddish brown semi-plastic clayey, gravelly; C-2
4	19.3	6.3	Sand, red, brown, and gray, clayey; C-3
			Hattiesburg formation
5	42.0	22.7	Clay, light gray plastic carbonaceous, very sandy; contains scattered pea-gravel; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 43

Location: T.4 N., R.13 W., Sec. 29, SW.1/4, SW.1/4: 0.9 mile south of Southern Railway overpass on Highway U. S. 11 and 60 feet west of pavement

Drilled: May 3, 1939

Elevation: 251 feet

Water level: 20.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.7	0.7	Topsoil
2	5.8	5.1	Sand, light brown and red slightly clayey
3	13.4	7.6	Clay, light brown and gray sandy; stained with limonite; P-1
4	26.1	12.7	Clay, gray plastic carbonaceous, limey; C-2

J. S. TURNER PROPERTY

TEST HOLE 46A

Location: T.3 N., R.13 W., Sec. 6, SW.1/4, SW.1/4; 0.7 mile south of Highway U. S. 11 at road intersection and 50 feet west of road

Drilled: October 18, 1939

Elevation: 353 feet

Water level: 15.4 feet

No.	Depth	Thick.	Description of strata
			Citronelle formation (?)
1	1.2	1.2	Topsoil
2	13.0	11.8	Sand, dark brown fine grained; contains scattered pea-gravel; C-1
			Hattiesburg formation (?)
3	47.3	34.3	Clay, variegated red and gray plastic sandy; contains scattered gravel; P-1

W. J. MORRIS PROPERTY

TEST HOLE 47

Location: T.4 N., R.13 W., Sec. 20, NW.1/4, NE.1/4; 800 feet north of road junction on Highway U. S. 11 and 100 feet east of the highway

Drilled: May 11, 1939

Elevation: 217 feet Water level: 16.6 feet

No.	Depth	Thick.	Description of strata
			High Terrace (?)
1	0.8	0.8	Topsoil
2	5.9	5.1	Sand, light brown and gray coarse grained slightly clayey; contains scattered gravel; C-1
3	11.1	5.2	Sand, light gray fine grained very clayey; limonite stained; C-2
			Hattiesburg formation
4	18.7	7.6	Clay, light gray to light brown semi-plastic sandy, micaceous; P-1
5	35.2	16.5	Clay, light brown carbonaceous, limey; P-2
6	45.1	9.9	Clay, same as interval 5; P-3

P. B. JOHNSON PROPERTY

TEST HOLE 51

Location: T.4 N., R.13 W., Sec. 34, SW.1/4, SE.1/4; 0.8 mile south of road junction with Highway U. S. 49 and 300 feet west of the highway

Drilled: May 17, 1939

Elevation: 188 feet Water level: 21.4 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.2	0.2	Topsoil
2	14.5	14.3	Clay, light gray sandy limonitic; P-1
3	30.4	15.9	Clay, light gray lignitic, limey; C-1

MRS. M. L. RODES PROPERTY

TEST HOLE 57

Location: T.3 N., R.13 W., Sec. 11, SE.1/4, SW.1/4; 0.4 mile south of road junction with Highway U. S. 11 and 70 feet west of the highway

Drilled: May 24, 1939

Elevation: 207 feet Water level: 11.6 feet

No.	Depth	Thick.	Description of strata
			High Terrace
1	0.4	0.4	Topsoil
2	3.2	2.8	Sand, red clayey, gravelly; C-1
			Hattiesburg formation
3	11.6	8.4	Clay, light brown sandy, micaceous; mottled with red, yellow, and gray; C-2
4	12.5	0.9	Sand, light gray fine grained clayey, micaceous
5	13.7	1.2	Clay, red silty; interlaminated with gray clay; C-3
6	27.6	13.9	Clay, light gray plastic sandy; P-1

CITY OF HATTIESBURG PROPERTY

TEST HOLE 86

Location: T.4 N., R.13 W., Sec. 14, SW.1/4, SW.1/4; 80 feet north of gravel pit road at Mississippi Central Railroad spur and 40 feet west of the track

Drilled: June 19, 1939

Elevation: Water level: 8.2 feet

No.	Depth	Thick.	Description of strata
			Low Terrace
1	1.4	1.4	Topsoil
2	2.6	1.2	Sand, light brown fine grained, grit-bearing
3	8.2	5.6	Sand and gravel, light yellow and white coarse grained; the pebbles range in size upward to about 0.7 inch; C-2. Sample P-1 is a sample of the washed sand from the pit

Remarks: Hole drilled on banks of gravel pit said to be 40 or 50 feet in depth. Drilling below the water level was not feasible with hand tools. It is estimated that between 1,500,000 and 2,000,000 cubic yards of the washed sand are available.

THE DIXIE TUNG EMPIRE CORP. PROPERTY

TEST HOLE 90

Location: T.1 S., R.12 W., Sec. 4, NW.1/4, SW.1/4; 0.25 mile north of overpass at abandoned railroad grade and 100 feet west of Highway U. S. 49

Drilled: June 20, 1939

Elevation: 215 feet

Water level: 4.8 feet

No.	Depth	Thick.	Description of strata
			Alluvium
1	0.6	0.6	Topsoil
2	7.4	6.8	Sand, light brown to white very fine grained; C-1
3	32.7	25.3	Clay, light gray to blue-gray plastic very sandy; contains isolated quartz and chert pebbles and fragments of white chalky material; P-1

LUTHER LOVETT PROPERTY

TEST HOLE 91

Location: T.5 N., R.14 W., Sec. 3, NE.1/4, NW.1/4; west side of gravel pit road, 0.3 mile north of Gulf and Ship Island Railroad crossing

Drilled: June 20, 1939

Elevation:—

Water level: 7.1 feet

No.	Depth	Thick.	Description of strata
			Low Terrace of Bouie River
1	0.7	0.7	Topsoil
2	2.3	1.6	Sand, light yellow to gray very fine grained silty, limonitic; C-1
3	6.5	4.2	Sand, light gray very fine grained silty; limonitic in part; C-2
4	7.7	1.2	Sand, gray to white coarse grained, gravel bearing; C-3. Sample P-1 is from the washed sand.

Remarks: Hole drilled near edge of gravel pit. It is estimated that a minimum of 1,000,000 to 1,500,000 cubic yards of the washed sand are available in the old pit.

FORREST COUNTY SAND AND GRAVEL CO. PROPERTY

TEST HOLE 93

Location: T.5 N., R.13 W., Sec. 33, NE.1/4, SE.1/4; 0.35 mile southeast of road junction at Hickory Grove Church and on the eastern bank of the gravel pit
Drilled: June 20, 1939

Elevation:—
Water level: 24.6 feet

No.	Depth	Thick.	Description of strata
			River alluvium
1	0.2	0.2	Topsoil
2	2.3	2.1	Clay, dark red sandy; contains scattered pea-gravel
3	9.1	6.8	Sand and gravel, very clayey; C-2
4	25.2	16.1	Sand and gravel, very clayey; C-3. Sample P-1 is from the washed sand in the old pit

Remarks: It is estimated that 3,500,000 to 4,000,000 cubic yards of the washed sand are available.

U. S. FORESTRY SERVICE PROPERTY

TEST HOLE 100

Location: T.2 N., R.12 W., Sec. 20, SW.1/4, SE.1/4; 1.6 miles south of bridge, 37987 and 300 feet east of Highway U. S. 49
Drilled: July 6, 1939

Elevation:—
Water level: 8.3 feet

No.	Depth	Thick.	Description of strata
			Pascagoula formation
1	0.6	0.6	Clay, light gray slightly sandy
2	1.8	1.2	Clay, dark brown sandy
3	17.1	15.3	Clay, dark to light gray plastic sandy, micaceous, carbonaceous; lower 2.0 feet stained with limonite; P-1
4	25.9	8.8	Sand, light red to gray clayey, micaceous, limonitic

TATUM LUMBER CO. PROPERTY

TEST HOLE 102

Location: T.4 N., R.13 W., Sec. 20, NE.1/4, SW.1/4; 190 feet west of road intersection and 40 feet east of road   Drilled: July 11, 1939

Elevation: 235 feet   Water level: 10.6 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation (?)
1	0.6	0.6	Topsoil
2	4.6	4.0	Clay, gray semi-plastic, sandy; C-1
3	19.6	15.0	Clay, variegated gray and red slightly carbonaceous; grades downward to light gray; P-1
4	20.5	0.9	Clay, variegated gray and red very plastic slightly sandy; C-2
5	21.5	1.0	Clay, variegated red and gray limey, sandy

TATUM LUMBER CO. PROPERTY

TEST HOLE 105

Location: T.4 N., R.13 W., Sec. 20, SE.1/4, SW.1/4; 0.2 mile west of road junction with Highway U. S. 11 and 70 feet south of road

Drilled: July 14, 1939

Elevation: 231 feet   Water level: 12.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation (?)
1	0.4	0.4	Topsoil
2	12.0	11.6	Sand, brown, gray, and white slightly clayey; C-1
3	17.5	5.5	Clay, light gray sandy; contains scattered small pebbles; in part consists of interbedded sand and clay; C-2
4	33.6	16.1	Clay, light brown and gray sandy, carbonaceous, limonitic; contains scattered gravel as large as 2 x 2½ inches; P-1
5	44.9	11.3	Clay, same as interval 4; C-3

TATUM LUMBER CO. PROPERTY

TEST HOLE 106A

Location: T.4 N., R.13 W., Sec. 20, NE.1/4, SW.1/4, 0.1 mile north of Southern Railway overpass and 60 feet west of Highway U. S. 11

Drilled: October 4, 1939

Elevation: 214 feet — Water level: 30.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.5	0.5	Topsoil
2	6.7	6.2	Clay, light gray and brown plastic slightly sandy, limonitic
3	21.7	15.0	Silt, variegated red, brown, yellow, and gray, plastic clayey, micaceous
4	25.5	3.8	Clay, light gray plastic sandy, limonitic
5	41.6	16.1	Silt, light gray clayey, limonitic
6	65.5	23.9	Clay, light bluish gray to brown carbonaceous, sandy, limonitic; some parts semi-consolidated; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 108

Location: T.4 N., R.13 W., Sec. 21, NW.1/4, SW.1/4; 100 feet south of Bonhomie, Hattiesburg and Southern Railroad and 150 feet east of gravel road

Drilled: July 19, 1939

Elevation: 202 feet — Water level: 32.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.6	0.6	Topsoil
2	32.0	31.4	Clay, light gray sandy, limey; mottled with brown limonitic stains; P-1
3	52.3	20.3	Clay, light gray plastic carbonaceous, very sandy; P-2
4	61.5	9.2	Clay, gray plastic sandy; partly limonite stained; C-1

JOHN B. BURKETT PROPERTY

TEST HOLE 117

Location: T.4 N., R.12 W., Sec. 29, NW.1/4, SE.1/4; 0.25 mile southeast of Carter's Creek bridge and 90 feet northeast of gravel road

Drilled: July 25, 1939

Elevation:—

Water level: Dry

No.	Depth	Thick.	Description of strata
			High Terrace
1	1.2	1.2	Topsoil
2	6.7	5.5	Sand, brownish gray fine grained clayey; grades downward to clay
3	8.8	2.1	Clay, variegated gray, red, and yellow, sandy
4	28.6	19.8	Sand, variegated light brown and white; contains pea-gravel; P-1

MISSISSIPPI SOUTHERN COLLEGE PROPERTY

TEST HOLE 121

Location: T.4 N., R.13 W., Sec. 7, SE.1/4, NW.1/4; 0.5 mile west of Administration Building at Mississippi Southern College and 90 feet south of road center

Drilled: July 26, 1939

Elevation: 232 feet

Water level: 30.4 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	1.0	1.0	Topsoil
2	6.6	5.6	Sand, light brownish gray semi-plastic limonitic; grades downward to clay; C-1
3	30.4	23.8	Clay, gray plastic sandy; stained red, purple, and light brown with limonite; P-1
4	31.3	0.9	Sand, gray clayey
5	37.6	6.3	Clay, gray semi-plastic sandy; C-2
6	49.8	12.2	Clay, gray and light brown hard massive sandy; P-2
7	57.5	7.7	Clay, same as interval 6; C-3
8	60.7	3.2	Clay, same as interval 6

MISSISSIPPI SOUTHERN COLLEGE PROPERTY

TEST HOLE 121A

Location: T.4 N., R.13 W., Sec. 7, SE.1/4, NW.1/4; 5.0 feet east of Test Hole 121
Drilled: October 26, 1939

Elevation: 232 feet
Water level: 26.5 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.6	0.6	Topsoil
2	10.4	9.8	Sand, gray and brown slightly clayey; C-1
3	30.1	19.7	Clay, light gray to light brown very sandy, micaceous; P-1
4	36.4	6.3	Sand, light gray coarse grained clayey, micaceous; C-2
5	61.4	25.0	Clay, light gray very sandy, carbonaceous; P-2

W. J. MORRIS PROPERTY

TEST HOLE 155

Location: T.4 N., R.13 W., Sec. 20, NW.1/4, NE.1/4; 800 feet north of road junction on Highway U. S. 11 and 400 feet east of the highway
Drilled: Sept. 20, 1939

Elevation: 217 feet
Water level: 6.0 feet

No.	Depth	Thick.	Description of strata
			High Terrace
1	0.8	0.8	Topsoil
2	11.4	10.6	Sand and gravel, light brown and gray clayey
3	27.7	16.3	Clay, light gray plastic very sandy; bears scattered small pebbles and limonite stains throughout; P-1
4	35.8	8.1	Clay, same as interval 3; P-2

W. J. MORRIS PROPERTY

TEST HOLE 156

Location: T.4 N., R.13 W., Sec. 20, NW.1/4, NE.1/4; 950 feet north of road junction on Highway U. S. 11 and 100 feet east of highway

Drilled: Sept. 21, 1939

Elevation: 231 feet

Water level: 18.5 feet

No.	Depth	Thick.	Description of strata
			High Terrace (?)
1	0.6	0.6	Topsoil
2	9.4	8.8	Sand, light brown slightly clayey
3	17.4	8.0	Clay, light gray semi-plastic silty, very limonitic; P-1
4	20.5	3.1	Sand, light gray coarse grained; stained with limonite
5	29.0	8.5	Clay, light gray plastic sandy, gravel-bearing; P-2
6	48.7	19.7	Clay, light brown; same as interval 5; P-3
7	58.8	10.1	Clay, brown; same as interval 6; P-4

TATUM LUMBER CO. PROPERTY

TEST HOLE 157

Location: T.4 N., R.13 W., Sec. 20, NE.1/4, SW.1/4; 0.2 mile north of Southern Railway overpass and 60 feet west of Highway U. S. 11

Drilled: Sept. 20, 1939

Elevation: 216 feet

Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.5	0.5	Topsoil
2	3.7	3.2	Silt, light gray and brown semi-plastic
3	37.3	33.6	Clay, bluish gray and brown massive plastic very silty, sandy, limey; P-1

W. J. MORRIS PROPERTY

TEST HOLE 158

Location: T.4 N., R.13 W., Sec. 20, NE.1/4, NW.1/4; 800 feet north of road junction on Highway U. S. 11 and 200 feet west of the highway

Drilled: Sept. 22, 1939

Elevation: 219 feet

Water level: 22.8 feet

No.	Depth	Thick.	Description of strata
			High Terrace
1	2.0	2.0	Topsoil
2	3.2	1.2	Sand, light brown clayey
3	41.0	37.8	Clay, interlaminated red, yellow, and gray, plastic sandy; contains a few scattered gravel in upper part; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 159

Location: T.4 N., R.13 W., Sec. 20, NE.1/4, SW.1/4; 0.1 mile north of Southern Railway overpass on Highway U. S. 11 and 485 feet west of the highway Drilled: Sept. 21, 1939

Elevation: 220 feet Water level: 18.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	1.3	1.3	Topsoil
2	18.5	17.2	Clay, light gray semi-plastic carbonaceous, slightly limey, sandy; limonite stained throughout; grades downward to sand; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 160

Location: T.4 N., R.13 W., Sec. 20, SE.1/4, SW.1/4; 250 feet north of Highway U. S. 11 underpass Drilled: Sept. 25, 1939

Elevation: 214 feet Water level: 19.5 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.5	0.5	Topsoil
2	3.5	3.0	Silt, light gray very sandy, limonite stained
3	15.2	11.7	Clay, reddish brown and gray semi-plastic sandy; P-1
4	29.2	14.0	Clay, gray; same as interval 3; P-2
5	32.7	3.5	Clay, same as interval 4
6	37.5	4.8	Sand, light gray fine grained clayey, limonitic

W. J. MORRIS PROPERTY

TEST HOLE 161

Location: T.4 N., R.13 W., Sec. 20, NW.1/4, NE.1/4; 0.1 mile north of road junction on Highway U. S. 11 and 100 feet east of the highway

Drilled: Sept. 25, 1939

Elevation: 224 feet Water level: 14.3 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation (?)
1	0.8	0.8	Topsoil
2	14.7	13.9	Sand, light brown and gray fine grained clayey
3	28.2	13.5	Clay, light gray plastic silty, stained with limonite; contains scattered small gravel; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 162

Location: T.4 N., R.13 W., Sec. 21, NW.1/4, SW.1/4; 100 feet south of Bonhomie, Hattiesburg and Southern Railroad and 150 feet west of gravel road

Drilled: Sept. 26, 1939

Elevation:— Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.9	0.9	Topsoil
2	6.9	6.0	Clay, reddish brown semi-plastic sandy; P-1
3	30.5	23.6	Clay, light gray semi-plastic slightly limey; P-2
4	43.7	13.2	Clay, same as interval 3; P-3

TATUM LUMBER CO. PROPERTY

TEST HOLE 163

Location: T.4 N., R.13 W., Sec. 29, NW.1/4, NE.1/4; 0.3 mile south of Southern Railway overpass on Highway U. S. 11 and 225 feet east of the highway Drilled: Oct. 2, 1939

Elevation: 236 feet Water level: 15.8 feet

No.	Depth	Thick.	Description of strata
			High Terrace
1	0.9	0.9	Topsoil
2	10.3	9.4	Sand, light brown and white clayey, limonitic; gravel-bearing in lower part
			Hattiesburg formation (?)
3	45.7	35.4	Clay, light gray plastic micaceous, slightly sandy; limonite stained in part; contains scattered gravel; P-1

G. SARTIN PROPERTY

TEST HOLE 164

Location: T.4 N., R.13 W., Sec. 17, SW.1/4, NW.1/4; 0.7 mile south of Hardy Street at road intersection and 90 feet east of section line road between Sections 17 and 18 Drilled: Sept. 27, 1939

Elevation:— Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	1.4	1.4	Topsoil
2	4.5	3.1	Sand, reddish brown very fine grained
3	37.5	33.0	Clay, variegated brown and gray, massive semi-plastic sandy; P-1
4	53.0	15.5	Clay, same as interval 3; P-3

W. J. MORRIS PROPERTY

TEST HOLE 165

Location: T.4 N., R.13 W., Sec. 20, NE.1/4, NW.1/4; 0.45 mile west along road crossing Highway U. S. 11 and 0.15 mile south of road

Drilled: Oct. 4, 1939

Elevation:—

Water level: 14.0 feet

No.	Depth	Thick.	Description of strata
			High Terrace
1	0.9	0.9	Topsoil
2	6.8	5.9	Sand, light brown fine grained grit-bearing, clayey
3	9.3	2.5	Clay, light gray plastic sandy, limonitic
4	10.1	0.8	Sand, light brown grit-bearing
			Hattiesburg formation
5	49.2	39.1	Clay, light gray plastic carbonaceous, slightly sandy; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 166

Location: T.4 N., R.13 W., Sec. 29, NE.1/4, NW.1/4; 0.25 mile south of Southern Railway overpass and 50 feet west of Highway U. S. 11

Drilled: Oct. 24, 1939

Elevation: 237 feet

Water level: 40.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.7	0.7	Topsoil
2	2.2	1.5	Sand, light brown slightly clayey; C-1
3	76.1	73.9	Clay, bluish gray massive plastic and semi-plastic slightly carbonaceous, slightly limey, limonitic: P-1
4	105.6	29.5	Clay, same as interval 3; P-2
5	120.6	15.0	Clay, brown and gray, same as interval 4

TATUM LUMBER CO. PROPERTY

TEST HOLE 167

Location: T.4 N., R.13 W., Sec. 29, NE.1/4, NW.1/4; 0.35 mile south of Southern Railway underpass and 50 feet west of Highway U. S. 11

Drilled: Oct. 6, 1939

Elevation: 242 feet

Water level: 12.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.2	0.2	Topsoil
2	63.9	63.7	Clay, light gray plastic sandy; upper few feet are streaked and mottled with limonite stains; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 168

Location: T.4 N., R.13 W., Sec. 29, SE.1/4, NW.1/4; 0.5 mile south of Southern Railway overpass and 200 feet west of Highway U. S. 11

Drilled: Oct. 3, 1939

Elevation: 244 feet | Water level: 24.6 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation (?)
1	0.9	0.9	Topsoil
2	3.5	2.6	Clay, light brown plastic sandy, limonitic; P-1
3	15.8	12.3	Sand, light gray and brown clayey
4	23.3	7.5	Clay, light brown plastic sandy, limonitic; P-2
5	34.5	11.2	Sand, light gray grit-bearing, clayey, limonitic

A. R. SUMRALL PROPERTY

TEST HOLE 169

Location: T.5 N., R.13 W., Sec. 31, SE.1/4, SW.1/4; 0.3 mile west of Hilltop House Nite Club and 30 feet south of gravel road

Drilled: Oct. 17, 1939

Elevation:— | Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.7	0.7	Topsoil
2	31.5	30.8	Clay, light gray and brown massive plastic very limey, limonitic; P-1
3	53.8	22.3	Silt, light bluish gray semi-plastic clayey, slightly micaceous; C-1

A. R. SUMRALL PROPERTY

TEST HOLE 170

Location: T.5 N., R.13 W., Sec. 31, NW.1/4, SW.1/4; 0.44 mile west of Hilltop House Nite Club and 50 feet north of gravel road

Drilled: Oct. 16, 1939

Elevation: 188 feet | Water level: 41.2 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.9	0.9	Topsoil
2	45.6	44.7	Clay, light gray plastic sandy, micaceous; P-1
3	48.4	2.8	Sand, light bluish gray very fine grained clayey

A. R. SUMRALL PROPERTY

TEST HOLE 171

Location: T.5 N., R.13 W., Sec. 31, SW.1/4, SE.1/4; 0.3 mile south of road junction on Highway U. S. 49 and 80 feet east of gravel road

Drilled: Oct. 17, 1939

Elevation:— Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.8	0.8	Topsoil
2	49.5	48.7	Clay, variegated gray red and brown plastic sandy, slightly limey, limonitic; P-1

J. S. TURNER AND SONS PROPERTY

TEST HOLE 172

Location: T.3 N., R.13 W., Sec. 7, NW.1/4, NW.1/4; 0.8 mile south of road intersection on Highway U. S. 11 and 50 feet west of highway

Drilled: Oct. 18, 1931

Elevation:— Water level: Dry

No.	Depth	Thick.	Description of strata
			Citronelle formation
1	1.2	1.2	Topsoil
2	5.5	4.3	Sand, gray and brown gravel-bearing, clayey; C-1
			Hattiesburg formation
3	21.5	16.0	Clay, light gray and brown plastic sandy, limonitic; P-1
4	45.1	23.6	Sand, yellowish brown slightly clayey; C-2

J. S. TURNER AND SONS PROPERTY

TEST HOLE 173

Location: T.3 N., R.13 W., Sec. 6, SE.1/4, SW.1/4; 0.7 mile south of road intersection on Highway U. S. 11 and 250 feet east of highway

Drilled: Oct. 18, 1939

Elevation:— Water level: Dry

No.	Depth	Thick.	Description of strata
			Citronelle formation (?)
1	1.0	1.0	Topsoil
2	5.6	4.6	Sand, light brown gravel-bearing; C-1
3	32.8	27.2	Clay, gray and red massive plastic sandy, slightly limey; P-1
4	53.5	20.7	Sand, gray and red clayey, gravel-bearing

TATUM LUMBER CO. PROPERTY

TEST HOLE 175

Location: T.4 N., R.13 W., Sec. 29, NE.1/4, SW.1/4; 0.8 mile south of Southern Railway overpass and 80 feet east of Highway U. S. 11

Drilled: Nov. 2, 1939

Elevation:— Water level: 25.9 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.4	0.4	Topsoil
2	11.5	11.1	Clay, variegated gray, red, and brown, semi-plastic, sandy; P-1
3	12.9	1.4	Silt, light gray sandy; C-1
4	39.6	26.7	Clay, light gray and brown plastic slightly sandy; P-2

W. G. GILLESPIE PROPERTY

TEST HOLE 179

Location: T.4 N., R.13 W., Sec. 7, SW.1/4, SW.1/4; 0.3 mile south of intersection of Highway U. S. 24 and 37th Avenue Drilled: Oct. 26, 1939

Elevation:— Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.6	0.6	Topsoil
2	2.4	1.8	Sand, brown semi-plastic clayey
3	8.8	6.4	Clay, light gray plastic slightly sandy, limonitic; P-1
4	13.2	4.4	Sand, gray and brown clayey, limonitic; C-1
5	50.4	37.2	Clay, gray plastic carbonaceous, limonitic, slightly limey; P-1

TATUM LUMBER CO. PROPERTY

TEST HOLE 180

Location: T.4 N., R.13 W., Sec. 21, SW.1/4, SW.1/4; 0.4 mile south of Bonhomie and Hattiesburg Southern Railway crossing and 90 feet west of gravel road
Drilled: Oct. 31, 1939
Elevation:—
Water level: 15.2 feet

No.	Depth	Thick.	Description of strata
			High Terrace
1	1.3	1.3	Topsoil
2	8.5	7.2	Sand, light brown and red; C-1
3	14.7	6.2	Clay, light gray semi-plastic limonitic, slightly sandy; P-1
4	16.8	2.1	Sand, pink coarse grained gravel-bearing; C-2
			Hattiesburg formation (?)
5	38.4	21.6	Clay, gray and brown plastic limonitic, slightly sandy; P-2

A. E. NORTON PROPERTY

TEST HOLE 181

Location: T.4 N., R.13 W., Sec. 7, NE.1/4, SW.1/4; 400 feet south of Highway U. S. 24 and 60 feet east of 37th Avenue
Drilled: Nov. 3, 1939
Elevation:—
Water level: Dry

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.7	0.7	Topsoil
2	1.8	1.1	Sand, light brown, very fine grained clayey
3	42.5	40.7	Clay, variegated gray, brown, and red, very plastic sandy; P-1

STATE OF MISSISSIPPI PROPERTY

TEST HOLE 182

Location: T.1 N., R.12 W., Sec. 16, SE.1/4, SE.1/4; 0.5 mile south of road intersection and 80 feet east of Highway U. S. 49
Drilled: Nov. 2, 1939
Elevation:—
Water level: Dry

No.	Depth	Thick.	Description of strata
			Pascagoula formation
1	1.6	1.6	Topsoil
2	42.8	41.2	Clay, variegated gray, brown, and red semi-plastic sandy, very micaceous; P-1
3	43.8	1.0	Sand, light gray very fine grained limonitic

Tatum Lumber Co. Property

Test Hole 183

Location: T.4 N., R.13 W., Sec. 21, SW.1/4, SW.1/4; 0.35 mile south of Bonhomie and Hattiesburg Southern Railway crossing and 80 feet west of gravel road Drilled: Nov. 1, 1939
Elevation:— Water level: 34.5 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	1.5	1.5	Topsoil
2	3.7	2.2	Sand, brownish red fine grained clayey; C-1
3	41.5	37.8	Clay, gray plastic very limonitic, slightly sandy; P-1

State of Mississippi Property

Test Hole 184

Location: T.1 N., R.12 W., Sec. 16, SE.1/4, SE.1/4; 100 feet north of Test Hole 182 Drilled: Nov. 3, 1939
Elevation:— Water level: 19.0 feet

No.	Depth	Thick.	Description of strata
			Pascagoula formation
1	0.7	0.7	Topsoil
2	46.8	46.1	Clay, variegated gray and brown very plastic limonitic, slightly sandy; P-1
3	49.0	2.2	Sand, light gray very fine grained limonitic

U. S. Forestry Service Property

Test Hole 186

Location: T.1 N., R.12 W., Sec. 21, NE.1/4, NE.1/4; 0.7 mile south of road intersection and 80 feet east of gravel road Drilled: Nov. 6, 1939
Elevation:— Water level: 27.9 feet

No.	Depth	Thick.	Description of strata
			Pascagoula formation
1	0.2	0.2	Topsoil
2	10.8	10.6	Clay, gray and brown plastic slightly sandy; P-1
3	26.9	16.1	Silt, light gray semi-plastic clayey; P-2
4	30.0	3.1	Sand, light gray very fine grained silty, limonitic

State of Mississippi Property

Test Hole 187

Location: T.1 N., R.12 W., Sec. 16, SE.1/4, NE.1/4; 0.45 mile south of road intersection and 80 feet east of gravel road Drilled: Nov. 7, 1939
Elevation:— Water level: 3.4 feet

No.	Depth	Thick.	Description of strata
			Pascagoula formation
1	0.7	0.7	Topsoil
2	31.0	30.3	Clay, gray brown and red very plastic limonitic slightly sandy; P-1
3	32.4	1.4	Sand, light gray fine grained silty, limonitic

Laura Knox Property

Test Hole 189

Location: T.3 N., R.13 W., Sec. 3, NE.1/4, SE.1/4; 200 feet northeast of Test Hole 188 Drilled: Nov. 8, 1939
Elevation:— Water level: 10.1 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	0.2	0.2	Topsoil
2	1.9	1.7	Sand, light brown fine grained semi-plastic slightly clayey; C-1
3	9.5	7.6	Clay, light brown and gray plastic slightly sandy; P-1
4	10.2	0.7	Sand, light gray very fine grained; C-2
5	34.1	23.9	Clay, light gray plastic sandy, limonitic; P-2
6	35.0	0.9	Sand, light brown fine grained silty, very micaceous

P. B. Johnson Property

Test Hole 190

Location: T.4 N., R.13 W., Sec. 34, SE.1/4, SE.1/4; 0.7 mile south of road crossing on Highway U. S. 49 and 500 feet east of highway
Drilled: Nov. 8, 1939
Elevation:— Water level: 25.0 feet

No.	Depth	Thick.	Description of strata
			Hattiesburg formation
1	1.2	1.2	Topsoil
2	37.9	36.7	Clay, light gray and brown semi-plastic slightly sandy, carbonaceous; P-1

BIBLIOGRAPHY

1. Tharp, W. E., and Spann, W. M., Soil Survey of Forrest County, Mississippi: U. S. Department of Agriculture, Bureau of Soils, 1912.
2. Wailes, B. L. C., Report on the Agriculture and Geology of Mississippi, pp. 214-219, 1854.
3. Harper, L., Preliminary report of the geology and agriculture of the state of Mississippi, 1857.
4. Harper, L., op. cit., p. 157.
5. Hilgard, Eugene W., Report on the geology and agriculture of the State of Mississippi, pp. 147-154, 1860.
6. Hilgard, Eugene W., op. cit., p. 138.
7. Hilgard, Eugene W., The later Tertiary of the Gulf of Mexico, Am. Jour. Sci., 3rd. ser. vol. 22, pp. 58-65, 1881.
8. Johnson, Lawrence C., The Grand Gulf Formation of the Gulf States, Am. Jour. Sci., 3rd ser. vol. 38, pp. 213-216, 1889.
9. McGee, W. J., The Lafayette Formation, U. S. Geological Survey, 12th Annual Report, Pt. 1, p. 409, 1891.
10. Johnson, Lawrence C., The Miocene Group of Alabama, Science, vol. 21, No. 524, pp. 90-91, Feb. 17, 1893.
11. Dall, William H., A Table of North American Tertiary Horizons, U. S. Geol. Survey, 18th Annual Report, Pt. II, p. 334, 1898.
12. Maury, Carlotta Joaquina, A comparison of the Oligocene of Western Europe and the Southern United States, Bull. Am. Pal. Vol. III, No. 15, pp. 43, 70, and 74-76, June, 1902.
13. Harris, Gilbert D., and Veach, A. C., A preliminary report on the geology of Louisiana, La. State Exp. Sta., Geol. and Agri. La., Part V, pp. 98-99, 1899.
14. Harris, Gilbert D., The Tertiary Geology of the Mississippi Embayment, La. State Exp. Sta., Geol. and Agri. La., Pt. VI, pp. 28-32, 1902.
15. Smith, Eugene A., and Aldrich, Truman H., The Grand Gulf formation, Science, N.S., vol. XVI, pp. 835-837, Nov. 21, 1902.
16. Dumble, E. T., Geology of southwestern Texas; Trans. Am. Inst. Mining Eng., vol. 23, p. 922, 1903.
17. Veach, A. C., Geology and underground water resources of northern Louisiana and southern Arkansas; U. S. Geological Survey, Prof. Paper 46, pp. 42-43, 1906.
18. Darby, Williams, A geological description of the state of Louisiana, Philadelphia, pp. 45-46, 1816.
19. Wailes, B. L. C., op. cit., pp. 245-253, 1854.
20. Harper, L., op. cit., pp. 162, 182-240, 1857.
21. Safford, Jas. M., A geological reconnaissance of the state of Tennessee, Nashville, Tenn., p. 162, 1856.
22. Hilgard, Eugene A., op. cit., pp. 4-29, 1860.
23. McGee, W. J., loc. cit., 1891.

FORREST COUNTY MINERAL RESOURCES TESTS

THOMAS EDWIN McCUTCHEON, B.S., CER. ENGR.

INTRODUCTION

The clays of Forrest County appear to be of the same general type even though they were sampled from different stratigraphic positions and from different areas in the county. From the routine tests no distinguishing characteristics were detected that would place a series of samples in a distinct geologic horizon, on the other hand, certain characteristics common to all clay samples were evident and would suggest a common origin for the clays from different geologic horizons. The most distinguishing characteristic common to all samples is the presence of appreciable amounts of what may be described as small nodules of lightly cemented opaque silt grains. The nodules have a waxy appearance and though they resist disintegration by water they are easily broken down by mild pressure. Qualitative tests show that the washed and dried nodules lose 2 to 4 percent weight on ignition and 85 percent weight on treatment with hydroflouric acid. The silt does not appear to be chemically different from the bulk of the clay.

The physical properties imparted to the clay by different amounts of silt nodules account for the principal difference between the clay samples. During drying and burning the silt decreases shrinkage and in this respect is beneficial. However, the silt composed principally of quartz expands and contracts to such an extent during the burning and cooling cycles that a number of the larger test pieces cracked and modulus of rupture values could not be determined. Test pieces from other samples were affected to a lesser degree and gave representative modulus of rupture values.

The samples tested have been divided into three groups. The division is based on the cone temperature at which the clays begin to overburn. This division is about the only group classification in which the clays can be placed that will designate some distinct difference in properties.

CLAYS WHICH OVERBURN AT CONE 10

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in lbs./sq. in	Texture	Color
		Volume in percent	Linear in percent			
F1AP1-3.7-50.6 ft.	28.42	40.50	15.89	278	Fine	Tan
F7P1-7.0-55.5 ft.	26.09	34.42	13.15	282	Fine	Tan
F12AP1-0.8-43.6 ft.	29.72	42.28	16.75	410	Fine	Tan
F106A-41.6-65.5 ft.	26.43	42.74	16.99	128	Fine	Tan
F121AP1-10.4-30.1 ft.	25.59	38.68	15.05	347	Fine	Tan
F155-11.4-35.8 ft.	28.42	44.18	17.67	355	Fine	Tan
F156-20.5-58.8 ft.	25.76	38.34	14.91	298	Fine	Tan
F162-0.9-43.7 ft.	36.54	38.16	14.82	360	Fine	Tan
F164P1-4.5-37.5 ft.	24.49	35.67	13.69	312	Fine	Tan
F164P2-37.5-53.0 ft.	28.18	40.35	15.84	348	Fine	Tan
F167X-0.2-63.9 ft.	27.10	42.22	16.75	283	Fine	Tan
F169-0.7-31.5 ft.	31.16	48.22	19.74	272	Fine	Tan
F171P1-0.8-49.5 ft.	29.65	45.25	18.22	343	Fine	Tan
F179-13.2-50.4 ft.	26.02	35.87	13.78	329	Fine	Gray

SCREEN ANALYSES*

SAMPLE F1AP1-3.7-50.6 FT.

Retained on screen	Percent	Character of residue
30	.25	Abundance of nodules of cemented opaque silt grains; small amounts of quartz and calcareous nodules; trace of magnetite.
60	2.79	Abundance of nodules of cemented opaque silt grains; small amounts of calcareous nodules and quartz; traces of hematite and ferro-manganese mineral.
100	5.45	Abundance of nodules of cemented opaque silt grains; small amounts of hematite and quartz.
150	2.89	Abundance of nodules of cemented opaque silt grains: considerable quantity of quartz; small amount of hematite; traces of muscovite and ferro-manganese mineral.
200	5.61	Abundance of nodules of cemented opaque silt grains; considerable quantitites of quartz and hematite; trace of ferro-manganese mineral.
250	1.97	Abundance of quartz; small amount of nodules of cemented opaque silt grains; traces of muscovite, magnetite and ferro-manganese mineral.
Cloth	81.04	Clay substance including residue from above.

SAMPLE F7P1-7.0-55.5 FT.

Retained on screen	Percent	Character of residue
30	.47	Abundance of limonitic stained nodules of cemented silt grains; traces of ferro-manganese mineral and calcareous material.
60	2.30	Abundance of limonitic stained nodules of cemented silt grains; small amount of calcareous nodules; trace of ferro-manganese mineral.
100	4.22	Abundance of limonitic stained nodules of cemented silt grains; traces of quartz, calcareous material and ferro-manganese mineral.
150	2.69	Abundance of limonitic stained nodules of cemented silt grains; small amount of quartz; trace of ferro-manganese mineral.
200	7.47	Abundance of quartz; considerable quantity of limonitic stained cemented silt grains; trace of ferro-manganese mineral.
250	2.58	Abundance of quartz; traces of nodules of cemented opaque silt grains—some limonitic stained and ferro-manganese mineral.
Cloth	80.27	Clay substance including residue from above.

SAMPLE F169-0.7-31.5 FT.

Retained on screen	Percent	Character of residue
30	.83	Abundance of nodules of cemented opaque silt grains; small amount of limonitic stained nodules of cemented silt grains.
60	4.03	Abundance of limonitic stained nodules of cemented silt grains; small amount of nodules of cemented opaque silt grains.
100	5.46	Abundance of limonitic stained nodules of cemented silt grains; small amount of nodules of cemented opaque silt grains; trace of ferro-manganese mineral.
150	4.89	Abundance of limonitic stained nodules of cemented silt grains; considerable quantity of quartz; trace of ferro-manganese mineral.
200	5.64	Abundance of limonitic stained nodules of cemented silt grains; considerable quantity of quartz; traces of ferro-manganese mineral and muscovite.
250	.26	Abundance of quartz; considerable quantity of limonitic stained nodules of cemented silt grains.
Cloth	78.89	Clay substance including residue from above.

SAMPLE F179-13.2-50.4 FT.

Retained on screen	Percent	Character of residue
30	.56	Abundance of nodules of cemented opaque silt grains; considerable quantity of calcareous nodules.
60	.76	Abundance of nodules of cemented opaque silt grains; considerable quantity of calcareous nodules; trace of ferruginous material.
100	2.60	Abundance of calcareous nodules; considerable quantity of nodules of cemented opaque silt grains; trace of ferruginous material.
150	2.85	Abundance of calcareous nodules; considerable quantity of nodules of cemented opaque silt grains; traces of ferruginous material and muscovite.
200	5.02	Abundance of quartz; considerable quantity of nodules of cemented opaque silt grains; small amount of calcareous nodules; traces of ferruginous material and muscovite.
250	.57	Abundance of quartz; traces of cemented opaque silt grains, muscovite and ferruginous material.
Cloth	87.64	Clay substance including residue from above.

*Alta Ray Gault, technician.

CHEMICAL ANALYSES*

SAMPLE F1AP1-3.7-50.6 FT.

Ignition loss 4.96	Titania, TiO_2 .... 0.88	Manganese, MnO_2 . 0.32
Silica, SiO_2 ......69.86	Lime, CaO 2.85	Potash, K_2O 0.72
Alumina, Al_2O_3 ..17.74	Magnesia, MgO ..Trace	Soda, Na_2O 0.68
Iron Oxide, Fe_2O_3. 2.94		

SAMPLE F7P1-7.0-55.5 FT.

Ignition loss 3.68	Iron Oxide, Fe_2O_3. 2.80	Magnesia, MgO ... 0.20
Silica, SiO_2 ......75.40	Titania, TiO_2 .... 0.90	Potash, K_2O 0.31
Alumina, Al_2O_3 ..13.98	Lime, CaO 1.73	Soda, Na_2O 0.95

SAMPLE F169-0.7-31.5 FT.

Ignition loss 7.04	Titania, TiO_2 .... 0.92	Manganese, MnO_2. 0.21
Silica, SiO_2 ......72.65	Lime, CaO 1.15	Potash, K_2O 0.20
Alumina, Al_2O_3 ..14.92	Magnesia, MgO ..Trace	Soda, Na_2O 0.49
Iron Oxide, Fe_2O_3. 2.84		

SAMPLE F179-13.2-50.4 FT.

Ignition loss 3.69	Iron Oxide, Fe_2O_3. 2.40	Magnesia, MgO .. 0.32
Silica, SiO_2 ......76.54	Titania, TiO_2 .... 0.84	Potash, K_2O 0.60
Alumina, Al_2O_3 ..13.77	Lime, CaO 1.77	Soda, Na_2O 0.82

*M. R. Livingston, analyst.

All samples ground to pass 100-mesh screen.

PYRO-PHYSICAL PROPERTIES

Test Holes F1AP1, F7P1, F12AP1, F106A, F121AP1, F155, F156

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
F1AP1 3.7-50.6 ft.	01	21.40	10.78	1.98	2.52	4.71	1.63	204*	Red St. H.
	2	20.21	10.14	1.99	2.52	5.21	1.80	1036*	Red
	4	20.05	9.85	2.02	2.52	6.63	2.29	1182*	Dk. red
	6	17.79	8.77	2.03	2.47	6.81	2.36	352*	Dk. red
	8	15.55	7.64	2.03	2.41	6.95	2.39	2839	Dk. red
	10	5.86	2.88	2.03	2.16	7.09	2.42	2778*	Reddish brown
F7P1 7.0-55.5 ft.	01	23.54	12.09	1.95	2.55	2.77	.94	909	Red St. H.
	2	20.70	10.38	1.99	2.51	5.21	1.80	1140	Red
	4	18.65	9.21	2.03	2.49	5.28	1.80	630*	Dk. red
	6	16.92	8.27	2.04	2.46	7.14	2.46	1007	Dk. red
	8	15.01	7.35	2.04	2.40	7.25	2.50	1586	Dk. red
	10	4.54	2.27	1.98	2.08	4.16	1.42	2473	Reddish brown
F12AP1 0.8-43.6 ft.	01	21.28	10.62	2.00	2.55	4.82	1.66	**	Red St. H.
	2	18.85	9.19	2.05	2.53	7.11	2.46	1249*	Red
	4	18.33	8.90	2.06	2.52	7.54	2.60	**	Dk. red
	6	16.09	7.76	2.07	2.47	9.13	3.17	**	Dk. red
	8	15.13	7.31	2.07	2.44	8.37	2.88	1292*	Dk. red
	10	7.14	3.43	2.07	2.20	8.56	2.95	**	Reddish brown
F106A 41.6-65.5 ft.	01	14.56	6.79	2.16	2.47	8.00	2.74	**	Red St. H.
	2	11.71	5.38	2.18	2.46	9.29	3.20	**	Red
	4	9.70	4.41	2.20	2.45	10.23	3.56	**	Dk. red
	6	9.55	4.33	2.20	2.44	10.56	3.67	**	Dk. red
	8	4.32	2.00	2.15	2.25	8.34	2.88	**	Dk. red
	10	8.15	4.04	2.04	2.22	3.27	1.11	**	Reddish brown
F121AP1 10.4-30.1 ft.	01	15.63	7.54	2.07	2.46	7.56	2.60	1436*	Red St. H.
	2	14.37	6.79	2.10	2.46	9.52	3.31	1761*	Red
	4	14.47	6.88	2.10	2.46	8.78	3.02	1765*	Dk. red
	6	11.67	6.41	2.16	2.44	11.87	4.14	1146*	Dk. red
	8	11.33	5.36	2.16	2.39	11.88	4.14	2347*	Dk. red
	10	8.93	4.73	1.90	2.08	—2.06	—.70	3952	Reddish brown Bl.
F155 11.4-35.8 ft.	01	19.14	9.35	2.04	2.52	5.25	1.80	1271*	Red St. H.
	2	16.45	7.90	2.07	2.49	6.51	2.25	2354*	Red
	4	16.39	7.91	2.08	2.48	6.90	2.34	2385*	Dk. red
	6	13.39	6.34	2.11	2.44	8.11	2.81	2870*	Dk. red
	8	13.03	6.19	2.11	2.42	7.90	2.71	2755*	Dk. red
	10	3.97	2.01	1.97	2.06	1.53	.54	2200*	Reddish brown
F156 20.5-58.8 ft.	01	18.00	8.37	2.07	2.53	3.82	1.32	1639*	Red St. H.
	2	15.51	7.39	2.10	2.49	5.57	1.90	2008	Red
	4	15.34	7.30	2.13	2.50	5.68	1.94	2069	Dk. red
	6	13.99	6.63	2.13	2.45	6.11	2.11	2695*	Dk. red
	8	10.85	5.13	2.12	2.38	7.00	2.39	2518	Dk. red
	10	4.83	2.32	2.08	2.18	5.43	1.87	2438*	Reddish brown

Abbreviations: St. H., steel hard; Bl., bloated
*Visible fire cracks in modulus of rupture bars
**Large fire cracks in modulus of rupture bars

TEST HOLES F162, F164P1, F164P2, F167X, F169, F171P1, F179

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
F162 0.9-43.7 ft.	01	18.77	9.18	2.04	2.52	4.89	1.66	1568*	Red St. H.
	2	16.92	8.11	2.08	2.52	6.70	2.29	3112	Red
	4	14.88	7.06	2.11	2.48	7.95	2.74	2485*	Dk. red
	6	13.33	6.27	2.12	2.45	8.34	2.88	3286	Dk. red
	8	6.82	2.87	2.13	2.29	8.57	2.95	3702	Dk. red
	10	11.19	5.89	1.90	2.14	—4.35	—1.29	2466	Reddish brown Bl.
F164P1 4.5-37.5 ft.	01	22.70	11.45	1.98	2.56	2.12	.74	1403*	Red
	2	20.84	10.50	1.98	2.51	2.87	.98	1885*	Red St. H.
	4	19.30	9.66	2.00	2.47	3.14	1.08	2045	Dk. red
	6	19.03	9.45	2.01	2.47	3.86	1.32	2120*	Dk. red
	8	19.86	9.93	2.00	2.50	3.51	1.21	2375	Dk. red
	10	10.17	4.85	2.09	2.33	7.47	2.57	2640	Reddish brown
F164P2 37.5-53.0 ft.	01	16.24	7.62	2.13	2.53	12.93	4.54	**	Red St. H.
	2	11.61	5.25	2.21	2.50	15.96	5.65	2376*	Red
	4	12.44	5.69	2.19	2.50	15.19	5.35	3204*	Dk. red
	6	8.13	3.65	2.23	2.43	16.75	5.95	**	Dk. red
	8	7.58	3.42	2.21	2.39	15.73	5.57	**	Dk. red
	10	17.10	9.91	1.76	2.13	—5.53	—1.90	3498	Reddish brown Bl.
F167X 0.2-63.9 ft.	01	15.24	7.27	2.09	2.48	6.79	2.32	**	Red St. H.
	2	14.09	6.66	2.11	2.46	7.28	2.50	2147*	Red
	4	12.49	5.86	2.13	2.44	8.26	2.85	**	Dk. red
	6	12.10	5.66	2.15	2.43	8.94	3.09	**	Dk. red
	8	9.55	4.46	2.14	2.37	9.26	3.20	**	Dk. red
	10	4.02	1.93	2.09	2.17	6.51	2.25	**	Reddish brown
F169 0.7-31.5 ft.	01	11.46	5.28	2.17	2.45	11.29	3.92	**	Red St. H
	2	8.28	3.73	2.22	2.42	13.27	4.65	**	Red
	4	6.62	2.99	2.22	2.37	13.36	4.68	3357	Dk. red
	6	5.78	2.65	2.18	2.31	12.41	4.35	**	Dk. red
	8	9.82	4.87	2.02	2.24	4.89	1.66	**	Dk. red
	10	27.05	17.24	1.57	2.15	—23.10	—8.38	**	Reddish brown Bl.
F171P1 0.8-49.5 ft.	01	14.00	6.54	2.14	2.49	9.69	3.34	**	Red St. H.
	2	12.93	5.94	2.17	2.49	10.78	3.74	2361*	Red
	4	11.67	5.35	2.18	2.46	11.06	3.85	2857	Dk. red
	6	10.32	4.72	2.19	2.39	11.59	4.03	**	Dk. red
	8	9.41	4.32	2.18	2.39	11.71	4.10	**	Dk. red
	10	17.88	10.00	1.79	2.18	—8.09	—2.78	**	Reddish brown Bl.
F179 13.2-50.4 ft.	01	23.87	12.41	1.97	2.60	1.16	.40	1750*	Red
	2	18.83	9.38	2.01	2.47	4.34	1.49	1982	Red St. H.
	4	17.76	8.73	2.03	2.47	5.48	1.87	2083	Dk. red
	6	15.80	7.63	2.07	2.46	6.91	2.39	2820*	Dk. red
	8	11.32	5.40	2.09	2.36	8.05	2.78	2641*	Dk. red
	10	3.54	1.72	2.06	2.14	6.62	2.29	2745	Reddish brown

Abbreviations: St. H., steel hard; Bl., bloated
*Visible fire cracks in modulus of rupture bars
**Large fire cracks in modulus of rupture bars

SUMMARY AND CONCLUSIONS

The clays for which tests have been made and for which data is given on the preceding pages constitute the group that begins to overburn at cone 10.

All of the clays have good plastic properties. The water of plasticity ranges between 25 and 29 percent, linear drying shrinkage between 13 and 18 percent and modulus of rupture between 275 and 350 pounds per square inch. The values for some individual clays are outside the general average.

Wet screen analyses of typical clays indicate that approximately 80 percent of the clay is fine enough to pass a 250 mesh screen. The residue, retained on the screens, consists principally of silt nodules, quartz sand, and iron bearing minerals.

Chemical analyses of several clays show that the silica content varies between 70 and 75 percent, alumina between 14 and 18 percent, and iron between 2 and 3 percent.

The clays burn to a rich red steel hard body at cone 01. Test pieces, 1x1x2 inch size, decrease in porosity and absorption and increase in shrinkage fairly consistently with advancing heat treatment. There were no visible cracks or evidence of unsatisfactory burning behavior in the small test pieces. Most of the larger test pieces, 1x1x7 inches, showed fire cracks on being burned at various temperatures and this accounts for the erratic modulus of rupture values. Fire cracks in clay products are detrimental to the quality of the product and are quite common when using highly siliceous clays. They usually occur during the cooling cycle of burning and can be lessened by slow cooling or annealing. The rate of firing and cooling of the laboratory kiln was equivalent to commercial tunnel kiln operations but is five to six times as fast as periodic kiln schedules.

In the preceding tables of the pyro-physical properties and in the column of modulus of rupture values, it is indicated that certain clays at certain temperatures were fire-cracked. The clays designated as having large fire cracks were ruptured to such an extent that modulus of rupture values could not be determined. These clays should be avoided for making any kind of structural clay products. The clays which showed no fire-cracks or only small cracks would likely be satisfactory if burned in periodic kilns where the heat treatment is of longer duration than in tunnel kilns or laboratory kilns.

Other qualities of the clays, especially their deep rich red color, smooth texture, low burning shrinkage, absence of soluble salts, early maturing temperature, long firing range, and excellent working properties, render them highly desirable for making face brick, roofing tile, salt glaze silo and structural tile, hollow partition tile, flower pots, drain tile, and common brick.

CLAYS WHICH OVERBURN AT CONE 12

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in lbs./sq. in	Texture	Color
		Volume in percent	Linear in percent			
F1-1.0-40.5 ft.	30.99	44.12	17.67	277	Fine	Lt. brown
F2A-1.6-59.1 ft.	26.13	28.29	10.50	221	Fine	Gray
F3-7.5-63.0 ft.	31.09	48.42	19.84	154	Fine	Gray
F14AP1-4.8-44.8 ft.	29.01	40.02	15.70	347	Fine	Tan
F43-5.8-26.1 ft.	29.63	44.24	17.72	396	Fine	Tan
F47-11.1-45.1 ft.	26.32	38.34	14.91	397	Fine	Tan
F102-4.6-19.6 ft.	28.44	43.34	17.28	371	Fine	Tan
F108P1-0.6-32.0 ft.	26.52	38.59	15.01	292	Fine	Tan
F108P2-32.0-52.3 ft.	26.37	40.32	15.84	310	Fine	Tan
F157P1-3.7-33.6 ft.	24.44	32.26	12.19	278	Fine	Tan
F158-3.2-41.0 ft.	23.07	29.17	10.87	266	Fine	Tan
F159-1.3-18.5 ft.	25.98	34.89	13.33	383	Fine	Tan
F160-3.5-29.2 ft.	24.72	34.41	13.15	312	Fine	Tan
F161-14.7-28.2 ft.	24.66	34.44	13.15	311	Fine	Tan
F163-10.3-45.7 ft.	23.11	31.09	11.68	285	Fine	Tan
F165-10.1-49.2 ft.	24.82	35.38	13.55	335	Fine	Tan
F170P1-0.9-44.7 ft.	26.09	36.07	13.87	275	Fine	Gray
F175-0.4-39.6 ft.	24.82	31.24	11.76	283	Fine	Tan
F180P2-16.8-38.4 ft.	19.45	23.70	8.62	264	Fine	Gray
F181P1-1.8-42.5 ft.	28.27	39.67	15.52	328	Fine	Tan
F182-1.6-42.8 ft.	27.00	40.73	16.03	410	Fine	Tan
F183-3.7-41.5 ft.	27.07	40.13	15.75	384	Fine	Tan
F184P1-0.7-46.8 ft.	25.19	35.50	13.59	275	Fine	Lt. brown
F186-0.2-26.9 ft.	28.28	38.35	14.91	160	Fine	Lt. brown

SCREEN ANALYSES*

SAMPLE F14AP1-4.8-44.8 FT.

Retained on screen	Percent	Character of residue
30	.12	Abundance of quartz; small amount of limonitic stained nodules of cemented silt grains.
60	.98	Abundance of nodules of cemented opaque silt grains —some stained with limonite; traces of ferro-manganese mineral and quartz.
100	3.14	Abundance of limonitic stained cemented silt grains—some nodules of cemented opaque silt grains; trace of quartz.
150	2.65	Abundance of nodules of cemented opaque silt grains —some limonitic stained; considerable quantity of quartz.
200	6.04	Abundance of nodules of cemented opaque silt grains —some limonitic stained; considerable quantity of quartz.
250	1.81	Abundance of quartz.
Cloth	85.26	Clay substance including residue from above.

SAMPLE F108P1-0.6-32.0 FT.

Retained on screen	Percent	Character of residue
30	.04	Abundance of nodules of cemented opaque silt grains —some limonitic stained; trace of carbonaceous material.
60	1.28	Abundance of nodules of cemented opaque silt grains —some limonitic stained; small amount of lignitized wood.
100	1.59	Abundance of nodules of cemented opaque silt grains; small amount of nodules of limonitic stained cemented silt grains; traces of quartz and lignite.
150	2.96	Abundance of nodules of cemented opaque silt grains; small amounts of nodules of limonitic stained cemented silt grains and quartz.
200	4.80	Abundance of quartz; small amounts of nodules of cemented silt grains and nodules of hematite.
250	.50	Abundance of quartz; trace of nodules of cemented opaque silt grains.
Cloth	88.83	Clay substance including residue from above.

SAMPLE F175-0.4-39.6 FT.

Retained on screen	Percent	Character of residue
30	.17	Abundance of limonitic stained nodules of cemented silt grains; trace of lignitized wood.
60	1.42	Abundance of limonitic stained nodules of cemented silt grains; considerable quantity of nodules of cemented opaque silt grains; trace of lignitized wood.
100	1.94	Abundance of limonitic stained nodules of cemented silt grains; considerable quantity of nodules of cemented opaque silt grains; small amounts of quartz and muscovite.
150	2.62	Abundance of nodules of cemented opaque silt grains; considerable quantity of quartz; small amount of limonite; trace of muscovite.
200	4.74	Abundance of nodules of cemented opaque silt grains; considerable quantity of quartz; trace of muscovite.
250	.33	Abundance of quartz, trace of nodules of cemented opaque silt grains.
Cloth	88.78	Clay substance including residue from above.

SAMPLE F181P1-1.8-42.5 FT.

Retained on screen	Percent	Character of residue
30	.05	Abundance of nodules of cemented opaque silt grains; considerable quantity of limonitic stained nodules of cemented silt grains; small amount of plant fragments.
60	1.11	Abundance of nodules of cemented opaque silt grains; considerable quantity of limonitic stained nodules of cemented silt grains; small amount of plant fragments.
100	2.86	Abundance of nodules of cemented opaque silt grains; small amounts of limonitic stained nodules of cemented silt grains and quartz.
150	1.38	Abundance of nodules of cemented opaque silt grains —some limonitic stained; considerable quantity of quartz; trace of muscovite.
200	4.44	Abundance of quartz; considerable quantity of nodules of cemented opaque silt grains.
250	1.73	Abundance of quartz; traces of muscovite and nodules of cemented opaque silt grains — some limonitic stained.
Cloth	88.43	Clay substance including residue from above.

*Alta Ray Gault, technician.

CHEMICAL ANALYSES*

SAMPLE F14P1-4.8-44.8 FT.

Ignition loss 3.91	Iron Oxide, Fe_2O_3. 0.96	Magnesia, MgO .. 0.09
Silica, SiO_2 ......74.44	Titania, TiO_2 .... 0.47	Potash, K_2O 0.22
Alumina, Al_2O_3 ..17.97	Lime, CaO 1.23	Soda, Na_2O 0.83

SAMPLE F108P1-0.6-32.0 FT.

Ignition loss 4.07	Iron Oxide, Fe_2O_3. 3.04	Magnesia, MgO .. 0.08
Silica, SiO_2 ......74.60	Titania, TiO_2 .... 0.86	Potash, K_2O 0.80
Alumina, Al_2O_3 ..15.03	Lime, CaO 0.21	Soda, Na_2O 1.16

SAMPLE F175-0.4-39.6 FT.

Ignition loss 3.94	Iron Oxide, Fe_2O_3. 2.24	Magnesia, MgO .. 0.96
Silica, SiO_2 ......76.32	Titania, TiO_2 .... 1.04	Potash, K_2O 0.29
Alumina, Al_2O_3 ..14.80	Lime, CaO 0.19	Soda, Na_2O 0.58

SAMPLE F181P1-1.8-42.5 FT.

Ignition loss 3.98	Iron Oxide, Fe_2O_3. 1.40	Magnesia, MgO .. 0.02
Silica, SiO_2 ......74.48	Titania, TiO_2 .... 0.56	Potash, K_2O 0.35
Alumina, Al_2O_3 ..16.99	Lime, CaO 1.11	Soda, Na_2O 0.75

*M. R. Livingston, analyst.
All samples ground to pass 100-mesh screen.

PYRO-PHYSICAL PROPERTIES

TEST HOLES F1, F2A. F3, F14AP1, F43, F47

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
F1 1.0-40.5 ft.	01	22.41	11.35	1.98	2.55	4.07	1.39	1278*	Lt. red	St. H.
	2	21.46	10.85	1.98	2.52	4.06	1.39	1420*	Red	
	4	20.74	10.36	2.00	2.53	4.96	1.70	1806*	Red	
	6	18.13	8.97	2.02	2.47	6.27	2.15	841*	Dk. red	
	8	16.52	8.15	2.03	2.43	6.28	2.15	2033*	Dk. red	
	10	10.29	4.95	2.08	2.32	9.21	3.20	2268	Reddish brown	
	12	7.52	4.06	1.85	2.00	—2.47	—.84	1090*	Greenish brown	Bl.
F2A 1.6-59.1 ft.	01	25.93	13.65	1.90	2.57	1.93	.67	847*	Lt. red	
	2	24.75	12.91	1.92	2.56	2.95	.70	1039*	Red	
	4	24.39	12.63	1.93	2.55	3.12	1.08	1705	Red	
	6	21.15	11.03	1.98	2.51	5.76	1.97	1860*	Dk. red	St. H.
	8	19.51	9.79	1.99	2.43	6.41	2.22	2165*	Dk. red	
	10	5.97	2.88	2.07	2.21	10.31	3.59	2125*	Reddish brown	
	12	4.37	2.31	1.88	1.97	1.31	.47	1686*	Greenish brown	
F3 7.5-63.0 ft.	01	17.92	8.72	2.05	2.50	5.97	2.04	**	Lt. red	St. H.
	2	17.31	8.42	2.06	2.49	6.00	2.04	**	Red	
	4	16.51	8.02	2.06	2.47	6.27	2.15	**	Red	
	6	14.71	7.07	2.08	2.44	7.12	2.46	**	Dk. red	
	8	14.60	7.02	2.08	2.44	8.01	2.78	**	Dk. red	
	10	7.05	3.41	2.10	2.27	9.33	3.24	**	Reddish brown	
	12	21.72	13.79	1.59	2.03	—20.91	—7.56	**	Greenish brown	Bl.
F14AP1 4.8-44.8 ft.	01	17.35	8.43	2.06	2.51	7.86	2.71	**	Lt. red	St. H.
	2	15.74	7.44	2.11	2.49	9.76	3.38	**	Red	
	4	13.58	6.37	2.14	2.47	10.33	3.59	3229*	Red	
	6	12.55	5.87	2.15	2.45	11.10	3.85	**	Dk. red	
	8	11.77	5.51	2.15	2.43	11.17	3.88	**	Dk. red	
	10	6.63	3.16	2.10	2.25	9.22	3.20	**	Reddish brown	
	12	18.55	11.55	1.66	2.02	—14.11	—4.98	N.D.	Greenish brown	Bl.
F43 5.8-26.1 ft.	01	18.21	8.99	2.02	2.48	5.09	1.73	1627*	Lt. red	St. H.
	2	16.50	8.02	2.05	2.46	6.86	2.36	2218*	Red	
	4	16.14	7.97	2.05	2.45	6.98	2.39	2284*	Red	
	6	15.17	7.30	2.08	2.45	8.14	2.81	3250*	Dk. red	
	8	13.52	6.42	2.11	2.44	8.94	3.09	3463	Dk. red	
	10	10.80	5.23	2.13	2.40	10.36	3.59	3530	Reddish brown	
	12	7.37	3.48	2.12	2.29	10.11	3.52	3138*	Greenish brown	
F47 11.1-45.1 ft.	01	17.65	8.63	2.05	2.49	3.97	1.35	2169*	Lt. red	St. H.
	2	16.70	8.08	2.07	2.48	5.89	2.01	2745	Red	
	4	16.31	7.90	2.07	2.47	6.16	2.11	2646*	Red	
	6	14.21	6.60	2.11	2.44	6.47	2.22	**	Dk. red	
	8	12.32	5.83	2.11	2.41	7.43	2.57	3076	Dk. red	
	10	9.49	4.43	2.14	2.37	8.13	2.81	3242*	Reddish brown	
	12	7.89	4.08	1.96	2.13	—.45	—.17	**	Greenish brown	Bl.

Abbreviations: St. H., steel hard; Bl., bloated
*Visible fire cracks in modulus of rupture bars
**Large fire cracks in modulus of rupture bars

TEST HOLES F102, F108P1, F108P2, F157P1, F158, F159

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
F102 4.6-19.6 ft.	01	15.85	7.79	2.03	2.42	6.71	2.32	442*	Lt. red	St. H.
	2	15.72	7.72	2.04	2.41	6.99	2.39	3026	Red	
	4	12.75	6.49	1.96	2.35	7.55	2.60	**	Red	
	6	12.31	5.94	2.07	2.36	8.45	2.92	**	Dk. red	
	8	14.13	6.78	2.08	2.42	9.09	3.13	1565*	Dk. red	
	10	9.79	4.63	2.12	2.35	10.40	3.59	4002	Reddish brown	
	12	16.53	8.86	1.88	2.25	3.72	1.28	**	Greenish brown	
F108P1 0.6-32.0 ft.	01	19.55	9.62	2.03	2.53	3.90	1.32	1334*	Lt. red	St. H.
	2	18.57	9.12	2.04	2.50	4.40	1.49	1820	Red	
	4	17.44	8.51	2.05	2.48	4.92	1.70	1607	Red	
	6	16.26	7.89	2.06	2.47	6.26	2.15	419*	Dk. red	
	8	13.48	6.44	2.09	2.42	6.58	2.25	1481*	Dk. red	
	10	6.60	3.07	2.15	2.29	8.95	3.09	**	Reddish brown	
	12	5.25	2.62	1.96	2.06	.89	.30	Bl.	Greenish brown	
F108P2 32.0-52.3 ft.	01	18.82	9.09	2.07	2.55	5.02	1.73	1734*	Lt. red	St. H.
	2	17.45	8.32	2.10	2.54	6.11	2.11	2710	Red	
	4	16.56	7.85	2.11	2.53	6.79	2.32	2804*	Red	
	6	14.27	6.70	2.13	2.49	7.47	2.57	2802*	Dk. red	
	8	11.62	5.40	2.15	2.44	8.31	2.88	3119	Dk. red	
	10	5.67	2.70	2.15	2.33	8.41	2.92	3197	Reddish brown	
	12	14.42	8.82	1.72	2.02	—14.82	—5.24	Bl.	Greenish brown	
F157P1 3.7-33.6 ft.	01	22.23	11.31	1.96	2.53	1.72	.60	1395*	Lt. red	St. H.
	2	20.46	10.27	1.99	2.50	3.11	1.08	1591*	Red	
	4	20.27	10.17	1.99	2.50	2.91	1.01	1710*	Red	
	6	18.66	9.28	2.01	2.47	4.06	1.39	2040	Dk. red	
	8	18.04	8.95	2.01	2.46	4.10	1.39	2257	Dk. red	
	10	5.50	2.61	2.10	2.23	7.91	2.74	2542	Reddish brown	
	12	4.69	2.56	1.83	1.92	3.25	1.11	1628*	Greenish brown	
F158 3.2-41.0 ft.	01	21.16	10.67	1.98	2.52	.70	.24	1496	Lt. red	St. H.
	2	20.47	10.21	2.00	2.52	1.70	.57	1640	Red	
	4	20.24	10.14	2.00	2.50	1.69	.57	1790	Red	
	6	18.34	9.11	2.01	2.47	2.10	.70	1920	Dk. red	
	8	18.13	9.00	2.02	2.46	2.76	.94	1995	Dk. red	
	10	13.65	6.59	2.07	2.39	4.75	1.63	2175	Reddish brown	
	12	7.70	3.76	2.05	2.22	3.14	1.08	Bl.	Greenish brown	
F159 1.3-18.5 ft.	01	21.07	10.92	1.96	2.50	2.26	.77	605	Lt. red	St. H.
	2	20.07	10.15	1.98	2.48	2.61	.91	1754	Red	
	4	20.07	10.11	1.98	2.48	3.05	1.04	2006	Red	
	6	19.07	9.59	1.99	2.47	3.23	1.11	**	Dk. red	
	8	18.79	9.41	2.00	2.46	3.94	1.35	2583	Dk. red	
	10	15.46	7.57	2.04	2.42	5.36	1.83	2840	Reddish brown	
	12	7.44	3.55	1.97	2.12	3.65	1.25	Bl.	Greenish brown	

Abbreviations: St. H., steel hard; Bl., bloated
*Visible fire cracks in modulus of rupture bars
**Large fire cracks in modulus of rupture bars

TEST HOLES F160, F161, F163, F165, F170P1, F175

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity		Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
F160 3.5-29.2 ft.	01	19.14	9.53	2.00	2.48	4.81	1.66	1776*	Lt. red	St. H.
	2	18.85	9.41	2.00	2.48	5.08	1.73	2296	Red	
	4	16.72	8.17	2.05	2.46	6.74	2.32	3036	Red	
	6	14.42	6.89	2.09	2.45	8.85	3.06	2540*	Dk. red	
	8	15.05	7.22	2.08	2.45	9.13	3.17	3203	Dk. red	
	10	6.52	3.08	2.12	2.27	10.16	3.52	3273	Reddish brown	
	12	20.88	12.23	1.71	2.17	—11.67	—4.06	Bl.	Greenish brown	
F161 14.7-28.2 ft.	01	20.26	10.05	2.02	2.53	3.56	1.21	1792*	Lt. red	St. H.
	2	18.18	8.86	2.05	2.52	4.72	1.63	1913	Red	
	4	17.68	8.68	2.05	2.49	5.31	1.83	1945	Red	
	6	16.44	7.94	2.07	2.48	5.91	2.04	2340	Dk. red	
	8	13.43	6.35	2.12	2.44	7.68	2.64	2757	Dk. red	
	10	6.69	3.12	2.14	2.30	8.92	3.09	2913	Reddish brown	
	12	4.25	2.13	1.99	2.08	1.67	.57	Bl.	Greenish brown	
F163 10.3-45.7 ft.	01	21.50	10.75	1.99	2.55	1.43	.50	1552	Lt. red	St. H.
	2	20.16	10.04	2.01	2.52	2.21	.77	1808	Red	
	4	19.62	9.81	2.01	2.50	2.32	.81	1830	Red	
	6	19.45	9.64	2.02	2.50	2.93	1.01	2013	Dk. red	
	8	16.57	8.19	2.05	2.47	4.54	1.56	2040	Dk. red	
	10	14.82	7.11	2.09	2.45	6.12	2.11	2148	Reddish brown	
	12	5.84	2.82	2.06	2.19	5.34	1.83	Bl.	Greenish brown	
F165 10.1-49.2 ft.	01	21.63	10.89	1.98	2.53	2.80	.94	1521*	Lt. red	St. H.
	2	20.44	10.14	2.02	2.50	4.51	1.56	2233	Red	
	4	20.17	10.08	2.00	2.51	3.20	1.08	1534	Red	
	6	17.87	8.86	2.02	2.46	4.26	1.46	2589*	Dk. red	
	8	17.34	8.55	2.05	2.47	5.78	1.97	2826*	Dk. red	
	10	4.51	2.17	2.07	2.18	7.25	2.50	2848	Reddish brown	
	12	12.98	7.34	1.79	2.05	—8.71	—3.02	2815*	Greenish brown	Bl.
F170P1 0.9-44.7 ft.	01	24.06	13.33	1.95	2.57	1.79	.60	955*	Lt. red	St. H.
	2	22.65	11.41	1.98	2.57	3.56	1.21	1404*	Red	
	4	20.72	10.41	1.99	2.51	3.65	1.25	1980*	Red	
	6	18.36	9.10	2.02	2.47	4.93	1.70	**	Dk. red	
	8	17.45	8.61	2.03	2.46	5.15	1.76	2188*	Dk. red	
	10	8.69	4.17	2.08	2.29	8.22	2.85	2441	Reddish brown	
	12	4.81	2.63	1.83	1.93	—4.51	—1.56	2375*	Greenish brown	Bl.
F175 0.4-39.6 ft.	01	23.00	11.64	1.95	2.53	2.36	.81	1384	Lt. red	St. H.
	2	22.68	11.53	1.96	2.53	3.04	1.04	1449	Red	
	4	22.32	11.40	1.96	2.52	3.11	1.08	1670	Red	
	6	20.45	10.15	1.97	2.49	3.45	1.18	2004	Dk. red	
	8	20.01	10.03	1.99	2.48	4.04	1.39	2054	Dk. red	
	10	15.92	7.73	2.06	2.45	5.84	2.01	2233	Reddish brown	
	12	8.71	4.28	2.03	2.23	6.45	2.22	2560	Greenish brown	

Abbreviations: St. H., steel hard: Bl., bloated
*Visible fire cracks in modulus of rupture bars
**Large fire cracks in modulus of rupture bars

TEST HOLES F180P2, F181P1, F182, F183, F184P1, F186

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
F180P2 16.8-38.4 ft.	01	26.16	13.30	1.97	2.57	—.45	—.17	1145	Lt. red	St. H.
	2	21.90	10.99	1.97	2.55	.00	.00	1175	Red	
	4	21.88	10.99	1.99	2.53	.00	.00	1515	Red	
	6	20.90	10.48	1.99	2.52	.87	.30	1702	Dk. red	
	8	20.20	10.11	2.00	2.50	.87	.30	1716	Dk. red	
	10	17.47	8.55	2.05	2.48	3.35	1.15	1824	Reddish brown	
	12	11.68	5.79	2.02	2.28	2.87	.98	1895	Greenish brown	
F181P1 1.8-42.5 ft.	01	20.50	10.30	1.99	2.51	2.42	.84	2049*	Lt. red	St. H.
	2	19.19	9.55	2.01	2.49	4.07	1.39	2077	Red	
	4	18.59	9.18	2.02	2.48	4.19	1.42	2089*	Red	
	6	15.93	7.85	2.03	2.42	5.34	1.83	2762*	Dk. red	
	8	16.40	8.03	2.04	2.44	5.36	1.83	2789*	Dk. red	
	10	4.75	2.24	2.12	2.23	8.84	3.04	3189*	Reddish brown	
	12	4.93	2.62	1.87	1.97	—3.23	—1.11	3365*	Greenish brown	Bl.
F182 1.6-42.8 ft.	01	20.26	10.18	1.99	2.50	3.24	1.11	175*	Lt. red	St. H.
	2	18.18	8.98	2.03	2.48	4.93	1.70	2525	Red	
	4	18.16	8.97	2.03	2.48	4.95	1.70	2757	Red	
	6	15.51	7.50	2.06	2.43	5.14	1.76	3293*	Dk. red	
	8	15.00	7.23	2.07	2.44	6.93	2.39	3365	Dk. red	
	10	13.09	6.24	2.10	2.42	7.94	2.74	3452	Reddish brown	
	12	5.48	2.75	1.99	2.11	2.96	1.01	3466	Greenish brown	
F183 3.7-41.5 ft.	01	19.59	9.74	2.01	2.50	3.59	1.21	2377*	Lt. red	St. H.
	2	17.32	8.47	2.04	2.47	5.22	1.80	2442*	Red	
	4	18.21	9.01	2.03	2.49	4.78	1.63	2078*	Red	
	6	15.74	7.65	2.06	2.44	6.33	2.18	2993*	Dk. red	
	8	9.48	4.47	2.12	2.34	6.36	2.18	2585*	Dk. red	
	10	9.40	4.39	2.14	2.36	9.33	3.24	2687	Reddish brown	
	12	5.66	2.82	2.00	2.13	3.86	1.32	3228	Greenish brown	
F184P1 0.7-46.8 ft.	01	23.05	11.66	1.98	2.57	1.31	.47	381*	Lt. red	St. H.
	2	22.23	10.77	1.98	2.52	2.18	.74	1830*	Red	
	4	21.61	10.72	1.98	2.52	2.24	.77	1829*	Red	
	6	20.33	10.20	1.99	2.50	3.02	1.04	2280*	Dk. red	
	8	14.95	7.35	2.03	2.39	3.11	1.08	2429*	Dk. red	
	10	13.98	6.71	2.08	2.42	7.42	2.57	343*	Reddish brown	
	12	4.76	2.38	2.00	2.10	3.74	1.28	1980*	Greenish brown	
F186 0.2-26.9 ft.	01	22.75	11.16	1.98	2.54	3.22	1.11	**	Lt. red	St. H.
	2	21.29	10.73	1.98	2.53	3.48	1.18	1635*	Red	
	4	19.41	9.69	2.00	2.48	4.38	1.49	570*	Red	
	6	18.99	9.42	2.02	2.48	5.01	1.73	**	Dk. red	
	8	15.40	7.52	2.04	2.42	5.42	1.87	657*	Dk. red	
	10	11.79	5.59	2.11	2.39	8.75	3.02	965*	Reddish brown	
	12	4.06	2.16	1.87	1.95	—2.87	—.98	Bl.	Greenish brown	

Abbreviations: St. H., steel hard; Bl., bloated
***Visible fire cracks in modulus of rupture bars**
****Large fire cracks in modulus of rupture bars**

SUMMARY AND CONCLUSIONS

The clays for which tests have been made and recorded on the preceding pages comprise the group that overburn at cone 12. These clays are very similar to those of the preceding group except for their higher overburning temperature.

These clays are plastic and have good working and drying properties. The water of plasticity ranges between 23 and 30 percent, linear drying shrinkage between 11 and 18 percent, and modulus of rupture between 260 and 400 pounds per square inch. Some individual clays are outside the range of the general average but not enough to be considered distinctive types.

Wet screen analyses of several clays show that approximately 85 percent of the clay is fine enough to pass 250 mesh screen. The residue retained on the screens is principally small nodules of opaque silt grains.

Chemical analyses of several clays vary within narrow limits and are typical of the analyses of the preceding group of clays. The ignition loss is approximately 4 percent, silica 75 percent, alumina 15 to 18 percent, and iron oxide 1 to 3 percent. Other minerals are present in amounts from a trace to 1.25 percent.

The clays burn to a rich red steel hard body at cone 01 and darken to a reddish brown at cone 10. Throughout the range there is little variation in shrinkage. Porosity and absorption decrease only slightly through cone 8 but decrease appreciably at cone 10, the maximum safe burning temperature. Although the clays do not become entirely vitreous before overburning they are sufficiently impervious throughout their burning range for use in weather resisting structural clay products. Certain clays were fire-cracked (noted in the tables of pyro-physical properties) to such an extent that they should be avoided. The fire cracks were not visible in small test pieces, but would likely give trouble on fast burning schedules.

By burning the clays under commercial periodic kiln conditions, those which were only slightly cracked under laboratory burning conditions are suitable for the manufacture of a wide variety of heavy clay products including face brick, roofing tile, structural tile, hollow partition tile, silo tile, salt glaze products, drain tile, flower pots, and common brick.

CLAYS WHICH OVERBURN AT CONE 14 AND ABOVE

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in lbs./sq. in	Texture	Color
		Volume in percent	Linear in percent			
F46A-13.0-47.3 ft.	21.37	26.08	9.59	226	Fine	Tan
F51-0.2-8.6 ft.	23.53	23.52	8.58	236	Fine	Tan
F57-14.1-27.6 ft.	21.73	29.71	11.13	293	Fine	Tan
F63-2.9-22.6 ft.	20.54	29.91	11.21	300	Fine	Lt. red
F90-7.4-22.5 ft.	25.53	35.47	13.59	309	Fine	Gray
F100-1.8-17.1 ft.	20.61	20.76	7.48	166	Fine	Tan
F156P1-9.4-17.4 ft.	20.96	19.09	6.82	242	Fine	Tan
F166-2.0-13.3 ft.	24.97	37.33	14.46	392	Fine	Tan
F167P1-0.2-63.9 ft.	28.89	46.83	19.02	505	Fine	Lt. brown
F172-5.5-21.5 ft	30.32	43.43	17.33	354	Fine	Lt. red
F173-5.6-32.8 ft.	24.94	33.40	12.67	256	Fine	Tan
F177-1.5-14.8 ft.	27.25	36.47	14.05	362	Fine	Lt. brown
F179-2.4-8.8 ft.	30.86	43.95	17.57	396	Fine	Lt. brown

SCREEN ANALYSES*

SAMPLE F100-1.8-17.1 FT.

Retained on screen	Percent	Character of residue
30	.09	Abundance of limonitic stained nodules of cemented silt grains; small amount of quartz.
60	1.13	Abundance of limonitic stained nodules of cemented silt grains; small amount of quartz; trace of lignite.
100	12.77	Abundance of quartz; small amount of limonitic stained nodules of cemented silt grains; trace of lignite.
150	18.82	Abundance of quartz; small amount of limonitic stained nodules of cemented silt grains; trace of dark minerals.
200	7.38	Abundance of quartz; small amount of limonitic stained nodules of cemented silt grains; trace of dark minerals.
250	.56	Abundance of quartz; small amount of limonitic stained nodules of cemented silt grains; trace of dark minerals.
Cloth	59.25	Clay substance including residue from above.

SAMPLE F172-5.5-21.5 FT.

Retained on screen	Percent	Character of residue
30	.24	Abundance of limonitic stained nodules of cemented silt grains; small amount of nodules of cemented opaque silt grains.
60	2.18	Abundance of limonitic stained nodules of cemented silt grains; considerable quantity of nodules of cemented opaque silt grains.
100	3.66	Abundance of nodules of cemented opaque silt grains; considerable quantity of limonitic stained nodules of cemented silt grains; small amount of quartz.
150	2.35	Abundance of quartz; considerable quantities of limonitic stained nodules of cemented silt grains and nodules of cemented opaque silt grains.
200	8.77	Abundance of quartz; considerable quantities of hematite and limonitic stained nodules of cemented silt grains.
250	3.00	Abundance of quartz; small amounts of hematite and limonitic stained nodules of cemented silt grains.
Cloth	79.80	Clay substance including residue from above.

*Alta Ray Gault, technician.

CHEMICAL ANALYSES*

SAMPLE F100-1.8-17.1 FT.

Ignition loss 3.69	Iron Oxide, Fe_2O_3. 0.94	Magnesia, MgO ..Trace
Silica, SiO_2 ......80.09	Titania, TiO_2 .... 0.32	Potash, K_2O 0.06
Alumina, Al_2O_3 ..13.44	Lime, CaO 0.85	Soda, Na_2O 1.05

SAMPLE F172-5.5-21.5 FT.

Ignition loss 5.55	Iron Oxide, Fe_2O_3. 3.16	Magnesia, MgO ..Trace
Silica, SiO_2 ......72.94	Titania. TiO_2 .... 0.68	Potash, K_2O 0.19
Alumina, Al_2O_3 ..15.40	Lime, CaO 0.80	Soda, Na_2O 0.51

*M. R. Livingston, analyst.
All samples ground to pass 100-mesh screen.

PYRO-PHYSICAL PROPERTIES

TEST HOLES F46A, F51, F57, F63, F90, F100

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
F46A 13.0-47.3 ft.	01	25.20	13.14	1.91	2.56	—2.17	—.74	803	Lt. red
	2	24.44	12.67	1.93	2.55	—1.84	—.64	804	Lt. red St. H.
	4	25.09	13.09	1.92	2.56	—2.11	—.74	1070	Lt. red
	6	24.23	12.62	1.92	2.53	—1.40	—.47	1182	Red
	8	24.49	12.85	1.91	2.52	—2.07	—.70	1187	Red
	10	24.31	12.72	1.91	2.52	—1.75	—.60	1298	Red
	12	24.93	13.13	1.90	2.53	—2.50	—.84	1349	Reddish brown
	14	24.63	13.18	1.87	2.48	—4.67	—.59	1981	Reddish brown
F51 0.2-8.6 ft.	01	30.32	16.94	1.79	2.58	—1.74	—.60	932	Lt. red
	2	26.05	14.33	1.84	2.50	—1.05	—.37	1095	Lt. red St. H.
	4	26.41	14.39	1.84	2.50	—1.62	—.57	1054	Lt. red
	6	25.79	14.32	1.85	2.48	— .94	—.33	1335	Red
	8	24.39	13.28	1.84	2.42	—1.31	—.47	1388	Red
	10	24.63	13.38	1.84	2.44	— .79	—.27	1763	Red
	12	25.30	13.48	1.85	2.47	—1.46	—.50	2043	Reddish brown
	14	23.68	12.89	1.82	2.38	—1.85	—.64	2499	Reddish brown
F57 14.1-27.6 ft.	01	20.56	10.35	1.99	2.51	.99	.33	1760*	Lt. red
	2	19.01	9.42	2.02	2.49	1.95	.67	2071	Lt. red St. H
	4	18.75	9.32	2.02	2.48	2.59	.87	2622	Lt. red
	6	16.82	8.26	2.03	2.45	2.80	.94	2662	Red
	8	15.66	7.84	2.04	2.43	2.95	1.01	2488	Red
	10	14.20	6.77	2.05	2.38	3.31	1.15	**	Red
	12	11.32	5.32	2.03	2.32	4.51	1.56	**	Reddish brown
F63 2.9-22.6 ft.	01	22.93	11.40	1.98	2.57	.00	.00	1033*	Lt. red
	2	21.83	10.98	1.99	2.55	.00	.00	1238*	Lt. red St. H.
	4	22.48	11.37	1.98	2.56	.00	.00	1268*	Lt. red
	6	20.76	10.56	1.99	2.52	.00	.00	1048*	Red
	8	20.71	10.41	1.99	2.51	.00	.00	2619*	Red
	10	20.14	10.10	2.00	2.50	.71	.27	2485*	Red
	12	20.41	9.90	2.07	2.60	2.26	.77	N.D.	Reddish brown
	14	19.29	9.89	1.95	2.42	2.63	.91	N.D.	Reddish brown
F90 7.4-22.5 ft.	01	22.21	11.74	1.95	2.50	1.70	.57	1348*	Lt. red
	2	21.94	11.61	1.95	2.49	2.14	.74	1616	Lt. red St. H.
	4	19.95	10.23	1.96	2.48	2.26	.77	2105	Lt. red
	6	19.88	10.04	1.98	2.47	3.22	1.11	2130	Red
	8	16.91	8.47	2.00	2.41	3.25	1.11	2130	Red
	10	16.64	8.23	2.02	2.42	5.53	1.90	2327	Red
	12	14.99	7.41	2.07	2.44	7.08	2.42	2956	Reddish brown
	14	5.76	2.85	2.06	2.16	5.50	1.87	2644	Reddish brown
F100 1.8-17.1 ft.	01	28.07	14.95	1.88	2.61	—2.35	—.81	576	Lt. red
	2	28.08	14.99	1.88	2.61	—2.17	—.74	644	Lt. red St. H.
	4	27.55	14.63	1.88	2.60	—2.18	—.74	656	Lt. red
	6	26.81	14.36	1.89	2.59	—2.05	—.70	714	Red
	8	26.36	14.15	1.90	2.58	—2.21	—.77	779	Red
	10	25.93	13.74	1.90	2.56	—2.02	—.70	855	Red
	12	25.34	13.38	1.90	2.54	—2.02	—.70	940	Reddish brown
	14	23.11	12.09	1.91	2.49	— .68	—.24	1148	Reddish brown

Abbreviations: St. H., steel hard

*Visible fire cracks in modulus of rupture bars

**Large fire cracks in modulus of rupture bars

TEST HOLES F156P1, F166, F167P1, F172, F173, F177

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
F156P1 9.4-17.4 ft.	01	28.42	15.27	1.86	2.60	—1.78	—.60	1039	Lt. red	
	2	27.69	14.85	1.87	2.59	—1.36	—.47	N.D.	Lt. red	St. H.
	4	27.09	14.48	1.87	2.56	—1.25	—.44	N.D.	Lt. red	
	6	26.10	13.91	1.88	2.53	—1.25	—.44	N.D.	Red	
	8	26.27	14.04	1.87	2.54	—1.49	—.50	N.D.	Red	
	10	24.90	13.32	1.88	2.50	—1.34	—.43	N.D.	Red	
	12	26.40	14.20	1.86	2.53	—1.82	—.64	N.D.	Reddish brown	
	14	25.93	14.10	1.84	2.49	—2.90	—.98	N.D.	Reddish brown	
F166 2.0-13.3 ft.	01	20.06	10.10	1.98	2.48	3.43	1.18	2264*	Lt. red	
	2	19.71	9.95	1.98	2.47	3.64	1.25	3013*	Lt. red	St. H.
	4	17.69	8.83	2.00	2.44	3.74	1.28	**	Lt. red	
	6	17.21	8.57	2.01	2.42	3.79	1.28	**	Red	
	8	17.59	8.74	2.01	2.44	4.50	1.52	2805	Red	
	10	16.42	8.12	2.02	2.42	4.76	1.63	3278*	Red	
	12	16.87	8.32	2.03	2.43	4.66	1.59	**	Reddish brown	
	14	14.85	7.49	1.99	2.33	2.93	1.01	3192	Reddish brown	
F167P1 0.2-63.9 ft.	01	16.22	7.90	2.05	2.45	5.90	2.01	**	Lt. red	
	2	15.24	7.47	2.04	2.41	5.35	1.83	**	Lt. red	St. H.
	4	14.39	7.07	2.04	2.37	5.28	1.80	**	Lt. red	
	6	14.18	6.94	2.05	2.38	5.75	1.97	**	Red	
	8	13.49	6.51	2.07	2.39	7.23	2.50	**	Red	
	10	12.28	5.86	2.10	2.39	8.22	2.85	3666	Red	
	12	10.56	5.17	2.09	2.35	8.30	2.85	2740*	Reddish brown	
	14	20.38	11.19	1.82	2.29	—5.17	—1.76	N.D.	Reddish brown	Bl.
F172 5.5-21.5 ft.	01	24.61	12.64	1.95	2.58	.48	.17	1376*	Lt. red	
	2	23.15	11.81	1.96	2.55	.82	.30	2053	Lt. red	St. H.
	4	22.86	11.72	1.95	2.51	.99	.33	1805*	Lt. red	
	6	22.23	11.27	1.97	2.53	1.47	.50	1325*	Red	
	8	22.20	11.28	1.97	2.53	1.60	.54	1291*	Red	
	10	20.96	10.60	1.99	2.52	2.41	.84	1280*	Red	
	12	21.27	10.96	1.95	2.47	1.43	.50	993*	Reddish brown	
	14	17.58	9.14	1.92	2.34	—1.11	—.40	2202	Reddish brown	
F173 5.6-32.8 ft.	01	24.53	12.84	1.91	2.54	— .89	—.30	1011	Lt. red	
	2	23.16	12.06	1.92	2.50	— .45	—.17	1101	Lt. red	St. H.
	4	23.69	12.38	1.92	2.51	— .73	—.27	1224	Lt. red	
	6	22.21	11.51	1.93	2.48	— .44	—.17	1326	Red	
	8	21.78	11.27	1.92	2.47	— .45	—.17	1657	Red	
	10	22.04	11.49	1.93	2.46	— .59	—.20	1628	Red	
	12	22.01	11.60	1.90	2.44	—1.33	—.47	1696	Reddish brown	
	14	22.76	12.05	1.89	2.44	—2.86	—.98	3237	Reddish brown	
F177 1.5-14.8 ft.	01	26.30	13.63	1.93	2.62	.50	.17	1524*	Lt. red	
	2	24.86	12.73	1.95	2.60	1.51	.54	1582*	Lt. red	St. H.
	4	25.24	13.02	1.93	2.60	.99	.33	1795	Lt. red	
	6	24.08	12.32	1.95	2.57	1.81	.64	803*	Red	
	8	23.65	12.07	1.96	2.56	1.96	.67	1616*	Red	
	10	22.23	11.32	1.97	2.53	2.29	.77	1840	Red	
	12	23.06	11.77	1.96	2.55	2.02	.70	N.D.	Reddish brown	
	14	21.51	11.07	1.94	2.48	1.00	.33	N.D.	Reddish brown	

Abbreviations: St. H., steel hard; Bl.. bloated
*Visible fire cracks in modulus of rupture bars
**Large fire cracks in modulus of rupture bars

TEST HOLE F179

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
F179 2.4-8.8 ft.	01	26.81	14.02	1.91	2.61	1.23	.44	776*	Lt. red	
	2	25.92	13.50	1.92	2.59	1.68	.57	1132*	Lt. red	St. H.
	4	25.34	13.18	1.92	2.58	1.82	.64	1605*	Lt. red	
	6	25.33	13.13	1.93	2.58	1.85	.64	2239*	Red	
	8	24.76	12.90	1.93	2.55	1.83	.64	2790	Red	
	10	23.76	12.26	1.94	2.54	2.77	.94	N.D.	Red	
	12	23.76	12.27	1.94	2.54	2.42	.84	N.D.	Reddish brown	
	14	21.52	11.26	1.91	2.44	.92	.33	N.D.	Reddish brown	

Abbreviations: St. H.. steel hard
*Visible fire cracks in modulus of rupture bars

SUMMARY AND CONCLUSIONS

This group of clays is similar in many respects to the two preceding groups which overburn at cones 10 and 12. The principal distinction is that the clays of this group overburn at cone 14 and above, and are more open-bodied throughout their burning range. They generally contain more silt and fine sand.

The clays have good plastic and working properties and dry without warping or cracking. The water of plasticity ranges between 20 and 30 percent, the average being near 20 percent. The linear shrinkage varies with individual clays between 8 and 17 percent. Green modulus of rupture values range between 166 and 550 pounds per square inch.

The wide fluctuations in physical properties between individual clays are due to similar fluctuations in plastic and nonplastic portions of the clays. This is illustrated by the accompanying screen analyses of two clays, one of which contains 79.8 percent material fine enough to pass a 250 mesh screen, the other contains only 59.25 percent fine enough to pass the 250 mesh screen.

Chemical analyses of the same clays show a nominal variation in percent of constituents present but do not vary in their silica to alumina ratios as would be expected judging from the screen analyses. This inconsistency further confirms the probability that the peculiar silt nodules are chemically similar to the bulk of the clay as suggested in the introductory paragraph of this report.

The clays burn to a light red steel hard body at cone 2. The color darkens at increasing temperatures to red, dark red, and reddish brown at cones 12 and 14. There is little alteration in porosity, absorption, and shrinkage from cone 01 through cones 10 and 12. Most of the clays are too open-bodied at all temperatures for exterior structural products. Clays F57-14.1-27.6 ft., F90-7.4-22.5 ft., F166-2.0-13.3 ft., and F167P1-0.2-6.3 ft. burn to sufficiently impervious bodies over a wide firing range to be suitable for manufacture into exterior clay products such as face brick, hollow partition tile, structural tile, salt glaze products, drain tile, flower pots, and common brick. The clays should be slow burned in periodic kilns to lessen fire cracks and improve strength.

LABORATORY PROCEDURE

PREPARATION

Preliminary drying of the clays was unnecessary, for they had been collected from the field and stored in a steam-heated room 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; the residue coarser than 20-mesh was ground in a burr mill until it passed the 20-mesh screen. The final bit of residue remaining on the 20-mesh screen was collected for examination, the description of which appears in the tables of screen analyses under the designation "Residue retained on screen No. 20." 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 analyses, thermal analyses, chemical analyses, and for making pyrometric cones. Approximately 75 pounds of clay from the remainder were 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 three sizes: cubes, 1 inch square; short bars, 1 inch square by 2 inches long; 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 then pressing them 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. The 1 inch cubes were cut from short bars. 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, 100 short bars, and 4 cubes were made from each primary clay sample. Certain C 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 an overflow volunteer of the Schurecht type, using kerosene as the liquid. 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 were 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 and cubes were placed in dessicators, and on cooling to room temperature they were reweighed and placed in kerosene to soak 24 hours, after which, their volumes were taken as above described. The 1 inch cubes were slaked in water in accordance with the procedure outlined by the American Ceramic Society. Ten 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. Clays having a suitable plasticity were formed into pottery shapes by throwing on a potters wheel. Where the quantity of clay permitted, standard size brick were made in a hand mold for the purpose of observing drying characteristics of thick bodies. The water of plasticity, modulus of rupture, and volume of shrinkage, were calculated by methods outlined by the American Ceramic Society. The linear shrinkage was calculated from the volume of shrinkage and checked against the linear shrinkage measured from the long bars.

FIRED PROPERTIES

The long and short bars were burned in a downdraft surface combustion kiln especially designed for the purpose, using Butane gas 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 up to 200°F. below the optimum 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 pyrometric cones alone were used.

The fusion point of pyrometric cone equivalent of the several clays was determined in accordance with the standard procedure outlined by the American Ceramic Society, by using double tangent burners in a furnace especially designed for the purpose.

After the firing of the long and short pieces the kiln was cooled gradually in twenty-four to thirty-six hours, after which the short bars were immediately placed in dessicators 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 Schurecht volumeter using water as the liquid. 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 and six additional short bars were fired as check pieces for each clay and at each cone.

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	2,093
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.
25	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.

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 had apparently disintegrated.

The disintegrated clay in slip form was poured through a nest of Tyler standard screens, the sizes being 30, 60, 100, 150, 200, and 250-mesh. 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 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 clay nodules and though this could have been accomplished by blunging with rubber balls, it was not the purpose of this screen analyses to break the clay down to a finer state of division than would ordinarily occur in the usual commercial bungling procedure; consequently the screen analyses will show residue as "clay nodules" which indicate that a very thorough blunging will be necessary to completely disintegrate the clay.

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.

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 were 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; "trace," few grains scattered throughout residue.

CHEMICAL ANALYSES

Grinding: All samples were ground to pass a 100-mesh sieve.

Moisture: Moisture determinations were run on all samples as received, i.e., in an air-dried condition. An oven temperature of 110°C. was maintained on each sample for one hour.

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

Silica: Ignited samples were fused with 8 to 10 times their weight of anhydrous sodium carbonate, and the fusion dissolved in dilute hydrochloric acid. Double dehydrations of the silica with hydrochloric acid were carried out in all cases. The resulting silica was filtered off, ignited, weighed, volatilized by hydrofluoric acid, and the crucible reweighed. SiO_2 was found by difference.

Alumina: Alumina, iron, and titania were precipitated together by ammonium hydroxide in the presence of ammonium chloride. Double precipitations was found necessary to remove all chlorides. The mixed hydroxides were filtered off, washed free from chlorides, ignited, and weighed. This weight represents the total of alumina, iron, and titania. The mixed oxides were fused with potassium bisulfate, and dissolved in water. In a few cases small amounts of silica were recovered here by filtration, ignition, and volatilization with hydrofluoric acid. Accordingly, this was added to silica as determined and subtracted from alumina.

Iron: An aliquot of the solution of the bisulfate fusion was run through a Jones reductor and titrated with standard permanganate solution made up so that 1cc. is equivalent to 0.001 gram ferric oxide.

Titania: Another aliquot of the solution of the bisulfate fusion was placed in a nessler tube with a few drops of hydrogen peroxide and the color of the tube compared to standard color tubes.

The total of iron and titania was subtracted from the total of alumina, iron, and titania to leave the alumina.

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

Magnesia: Magnesia was determined in the lime filtrate by precipitation as the mixed ammonium phosphate. It was ignited and weighed as $Mg_2P_2O_7$.

Alkalies: Alkalies were determined by the J. Lawrence Smith method as outlined in Scott "Standard Methods of Chemical Analyses." The hydrofluoric acid method of decomposition was used because it was found to be more practical with the apparatus at hand.

Sulfur: Sulfur was determined in a separate sample by a carbonate fusion, solution in dilute hydrochloric acid, oxidation to SO_4 with bromine and precipitation with 10 percent barium chloride solution. Precipitate was weighed as barium sulfate. Ignition losses were corrected for SO_3 before totaling the analyses.

Duplicate analyses were made on each clay and the average was reported.