MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph. D.
Director

BULLETIN 57

MONROE COUNTY MINERAL RESOURCES

GEOLOGY

By

FRANKLIN EARL VESTAL, M. S.

TESTS

By

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

UNIVERSITY, MISSISSIPPI

1943

Frontispiece.—Covered bridge over James Creek on the Strongs road south of Aberdeen, about 1 mile south of the bentonite plant. July 31, 1942.

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

UNIVERSITY, MISSISSIPPI

1943

MISSISSIPPI GEOLOGICAL SURVEY

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LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi
December 11, 1943

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

Gentlemen:

Herewith is Bulletin 57, Monroe County Mineral Resources, Geology by Franklin Earl Vestal, M. S., and Tests by Thomas Edwin McCutcheon, B. S. Cer. Engr. It is published as a fulfillment in part of the Mississippi State Geological Survey sponsorship pledge to the W. P. A. which with Federal funds provided the field working force for drilling and collecting the samples and the laboratory working force for preparing the material for the tests—even though that organization was closed by Federal decree on March 6, 1943.

The geologic part by Mr. Vestal reveals the detailed painstaking investigations of the author, who had to prepare the report in parts, because of his present heavy teaching schedule of men in the armed forces.

Much the greater part of the report deals with economic geology, which includes oil and gas, bentonite, sand and gravel, ceramic clays, water, soils, agricultural limestone, woolrock, cement materials, and building rock.

The history of the oil and gas prospecting and the gas development have been treated rather fully even though the Amory Gas Field has ceased to produce. And even though definite geological structures favorable to oil and gas accumulation were not observed, elevations of a lignite zone near the Tuscaloosa-Eutaw contact were determined at a number of localities and recorded on Plate 2 in the hopes that such information would be of assistance to oil geologists in further surface or subsurface study of the area.

Such detailed treatment seems warranted in view of the fact that on April 11, 1942 the same author on page 71 of his Adams County Mineral Resources (Bulletin 47) described the faulted area near Cranfield and on page 89 of the report recommended this location for a test well; and that on May 20, 1943, the California Company began the drilling of their No. 1 National Gasoline Co. La. well in this area which on October 6, 1943, they completed as a natural gas and 56° gravity condensate oil in the massive sand at 10,226 to 10,276 feet.

Very sincerely yours

William Clifford Morse,
State Geologist and Director

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MONROE COUNTY MINERAL RESOURCES

GEOLOGY

FRANKLIN EARL VESTAL, M.S.

INTRODUCTION

Monroe County is bounded on the north by Itawamba and Lee Counties, on the west by Clay and Chickasaw, and on the south by Lowndes and Clay; it is bounded on the east by Lamar County of Alabama (Figure 1). All boundaries are straight except for a part of the southern, which follows Buttahatchie and Tombigbee Rivers. The northern boundary is about 29.5 miles long, the eastern 24.0 miles, and the western 28.0 miles; the width of the county, due east-

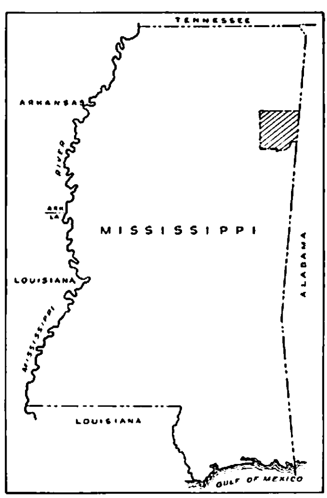

Figure 1.—Location of Monroe County.

west along the Clay County line and its eastward extension, is about 26.5 miles. The area is 769 square miles, making Monroe the eighth of the counties of the state in area. The population numbered 37,-648 by the 1940 census, of whom 8,473 were classed as "urban." Probably more than 75 percent ot the population are engaged in some form of agriculture. Cotton is the leading crop, especially in the lime region west of Tombigbee River, the prairie belt, but corn and hay and different sorts of cover crops are grown extensively, also; and divers other plants such as oats, sorghum, peanuts, potatoes, and fruits are cultivated sufficiently for local needs.[2] A considerable area is in forest, particularly in the hill districts, as in the eastern part of the county; also on the flood-plains adjacent to the stream channels, especially along Tombigbee and Buttahatchie Rivers and Sipsey, Splunge, and Weaver Creeks. Pines comprise a fair percentage of the woodlands, being most numerous in the hills, where commonly they occupy the summits and upper slopes, whereas the hardwoods take possession of the lower slopes and the valleys. Cedars may grow in any part of the county, but they flourish in the lime country, where dense thickets, such as the "cedar brakes" referred to in the text, are numerous; more often than not they are grouped on or around the "bald spots" of the chalk outcrop area, and thus are likely to be most conspicuous on eroded slopes, of which the bluffs of the Tombigbee and of Old Town Creek are prominent examples (Figure 6). The hardwoods include oaks of several varieties, hickory, poplar, ash, sycamore, gum, cypress, and others of lesser importance. Lumbering, although not so flourishing as it once was, still ranks well up among the industries of the county: large lumber yards at Aberdeen, Amory, Smithville, Quincy, and other places testify to the maintenance of the lumber business.

Monroe County has two sizeable towns—Aberdeen, which is the county seat, and Amory—and a number of larger and smaller villages: Smithville, Becker, Gattman, Greenwood Springs, Quincy, Hatley, Athens, Hamilton, New Hamilton, Bigbee, Wren, Muldon, Prairie, Gibson, Splunge, and perhaps another or two; Nettleton is on the county line, partly in Monroe County and partly in Lee. Aberdeen, on the west bluff of the Tombigbee 10 miles north of the southern boundary of the county, is a flourishing town of some 5,000 people (4,746 by the 1940 census),[1] known far beyond the county for its beautiful streets and homes. The chief industries are: the lumber industry, represented by at least four companies; the cottonseed oil industry and cotton ginning; and the bentonite processing industry. Among the numerous business establishments, the Lann and Carter Hardware Company probably is the largest. Aberdeen is a progressive little city which has recently experienced the greatest boom of its history through the building of the huge Gulf Ordnance plant near Prairie, some 8 miles west by south of Aberdeen. The construction company (Ferguson-Oman) employed many hundreds of workers, and the completed plant employs many hundreds. Aberdeen can be said to be "humming with activity," as the stock phrase has it. The town feels the effect of the comparative nearness of the Columbus Army Air Field, also. Amory, about 12 miles north by northeast of Aberdeen, stands on a terrace or second bottom of Tombigbee River 3.0 to 3.5 miles east of the river and at least 2.0 to 3.0 miles from the hills in any direction. The population numbered 3,727 in 1940.[1] Amory is an important center on the main line of the St. Louis and San Francisco Railroad which has its railroad shops here. Some of the large businesses are: the Gilmore-Puckett Lumber Company, the Abrams Lumber Company, the Amory Garment Company, the Amory Concrete Gravel Company, and the Amory Sand and Gravel Company. Several others of comparable importance could be named. Amory is a wide-awake, progressive town, numbering among its citizens several who for many years have been conspicuous in support of any sound plan for discovering and utilizing natural resources or for the fuller and more efficient use of those already known, or for the improvement of conditions in any manner. Smithville, about 8 miles northeast of Amory, is a farm and lumber village on the Mississippian Railroad. Gattman is just on the west side of the Mississippi-Alabama line, on the Frisco Railroad; it, too, is a farm and lumber village. Greenwood Springs, on the Frisco 4 miles west of Gattman, became locally well known some years ago because of its mineral springs; a large summer hotel, located at the springs, had a considerable number of guests each year. Becker, on the Frisco 3 miles south of Amory, is a farm village, as are the other villages named. Muldon, about 9 miles southwest of Aberdeen, is a shipping point for farm products, especially hay. Quincy, on the Frisco about 8 miles southeast of Amory, is the site of the T. F. Durrett Lumber Company saw and planing mill, one of the largest lumber mills of the county.

Three railroad systems are represented in Monroe County (Plate 1). The main line of the St. Louis and San Francisco (Frisco) crosses from northwest to southeast a little northeast of the center of the county; from its junction at Amory one division extends southeast to Birmingham, Alabama, and on to Jacksonville, Florida; the other leads south through Aberdeen, Columbus, and on to Pensacola. The Illinois Central extends a branch from Durant to Aberdeen. The Gulf, Mobile, and Ohio (formerly the Gulf, Mobile, and Northern and the Mobile and Ohio) crosses the southwestern corner of the county through Muldon, Prairie, and Gibson, and extends a branch from Muldon to Aberdeen.

The county is served by several main highways and a network of local roads (Plate 1). In the southwestern corner, U. S. Highway 45 W, a pavement highway, is located a little east of the western boundary for 13.6 miles; U. S. Highway 45 E, pavement, extends north-south across the county, from Nettleton on the northern boundary south to Aberdeen, thence east across Tombigbee River, and south through New Hamilton and across Buttahatchie River. Mississippi State Highway 41 within Monroe County terminates at Amory on the east and at the Chickasaw County line a little east of Okolona on the west; it connects Amory with U. S. Highway 45 W at Okolona. Highway 41 is blacktopped between Amory and U. S. Highway 45 E, 8 miles to the west; the remainder of it, to Okolona, is graveled. Mississippi State Highway 6, a good graveled road, crosses the county from Nettleton to Gattman, roughly paralleling the Frisco Railroad. Mississippi State Highway 25 extends across the county southwest-northeast along the Muldon-Aberdeen-Becker-Amory-Smithville route, very irregular in detail. All of it is graveled except the paved stretches through Aberdeen, Becker, and Amory, and a 5-mile paved stretch out of Amory towards Smithville. The local roads are in general all-weather roads, but this statement is more nearly accurate when applied to the part of the county east of Tombigbee River than to the western prairie region.

The county is served by gas pipe-lines of the Mississippi Public Service Company and electric power lines of the Tennessee Valley Authority, and the Monroe County Electric Power Association (Plate 1). The 8-inch gas pipe-lines of the Mississippi Public Service Company roughly parallel the Illinois Central Railroad on the east from the southern boundary of the county near Strongs to a border station a little southeast of Aberdeen, and the Frisco Railroad from this point to and slightly beyond a border station 1/4 mile or so east of Amory. At or near the Amory border station this 8-inch pipe-line joins a 10-inch line extending southeast-northwest from the old Amory gas field to Tupelo, north of and roughly parallel to the Frisco Railroad from Amory, and crossing the Monroe County-Lee County line a little east of Nettleton. Branches of the 8-inch line extend to Aberdeen and to Amory from the border station near each town. A Tennessee Valley Authority 44 KV. transmission line connects Okolona and Amory, and another TVA transmission line crosses from the Alabama line a little south of Gattman, to Aberdeen, thence south-southwest into Clay County by way of Strongs. The Monroe County Electric Power Association main lines are east of the Tombigbee River where they roughly follow Mississippi State Highways 25 and 6, but branches extend in various directions.

PHYSIOGRAPHY

PROVINCES, TOPOGRAPHY, AND RELIEF

Monroe County is near the inner or landward edge of the Gulf Coastal Plain which includes all Mississippi except the northeastern corner. It lies within part of the Tombigbee River Hills[4] or Fall Line Hills[3] physiographic province, and part of the Black Prairie belt, the western edge of the hills division being coincident with the western limit of the outcrop area of the Tombigbee Sand member of the Eutaw formation, roughly paralleling Tombigbee River a little west of the river (Plate 1).

The Tombigbee River Hills region is, in general, highest in the northeastern corner of the county, where a maximum elevation of about 500 feet above mean Gulf level is reached, and slopes west, south and southwest to a lowest point at the mouth of the Buttahatchie, where the elevation is not more than 150 feet. The maximum relief of the county is, then, 350 feet or more. The hills region is cut into sections by the deep Sipsey-Buttahatchie trenches, and to a lesser degree by Weaver and Splunge Creeks valleys and the valleys of smaller streams. The larger topographic features are these valleys and a series of north-south or northeast-southwest ridges between the valleys, but of course the ridges are in turn dissected by minor streams into more or less rounded hills. As a whole the topography may be said to have reached early maturity: little of the upland surface is flat-lying, and convex-upward profiles predominate; but in many places, notably near the heads of valleys, slopes are steep and ridges narrow. As described in one report:[4] "In northeastern Mississippi, in the area underlain by the predominantly sandy strata of the Tuscaloosa and Eutaw formations . . . the surface is generally hilly and ranges from low smoothly rounded hills of 40 or 50 feet relief, with broad intervening valleys, to hills and ridges of 200 feet relief, with steep slopes, narrow crests, and narrow separating valleys." Foster [3] distinguishes a "rugged phase" farther east and a "rolling phase" farther west. Stephenson and Monroe[5] distinguish between the Tuscaloosa type of topography and the Eutaw type, the topography of the Tuscaloosa outcrop area being "characterized by steep slopes and more or less conical but rounded hills, in general not as high as those underlain by the Eutaw formation farther west," and the topography of the Eutaw outcrop area showing in the east an upland featured by deep, steep-walled valleys and many relatively flat-topped hills, and in the west, where the Tombigbee sand member is at the surface, "irregular ridges and sharp conical peaks."

Along the larger stream valleys, particularly along Tombigbee River valley, terraces are conspicuous. The terrace belt along the eastern side of Tombigbee River in Monroe County is 4 to 5 miles wide in places. Stephenson and Monroe[5] found as many as five terrace plains of irregular width, in this belt. The terrace plains are said to slope gently upstream and to appear to merge with the present flood-plains of the main headwater branches of Tombigbee River in Monroe, Itawamba, and Lee Counties. A good example of terrace topography is the area a little north of McKinley Creek. A mile to 1.5 miles above the mouth of the creek the top of the river channel bank is 25 feet above low water; east of this, across a dry slough bed, the elevation is 7 to 8 feet greater; 1.7 miles by road still farther east is the face of a terrace composed of sand with a little gravel. This terrace rises sharply 30 to 35 feet above the river flat, and maintains its summit level eastwards to Highway 45 E, some 3 miles.[6]

The Black Prairie surface is undulating or rolling as a whole and of relatively slight relief, averaging 10 to 15 feet, and the maximum being not more than 40 feet. The topographic features are wide flat-bottomed valleys and low rounded hills having gentle slopes.[4, 5] No flat upland remains, and steep slopes are present only in places along streams where lateral planation has been effective, or at the heads of valleys. The surface slopes at a low angle towards the river and southwards. Narrow terraces have been left along some of the larger streams.[5]

DRAINAGE

All Monroe County lies within the drainage basin of Tombigbee River. The main river, designated on some maps East Fork of Tombigbee River, crosses the northern boundary of the county in Section 35, Township 11 South, Range 8 East, about 16.5 miles from the western boundary and 13.0 miles from the eastern. From this point its course is southwest 9 to 10 miles to its junction with Old Town Creek, or West Fork of Tombigbee River, from the northwest. From the confluence the river flows south to Aberdeen, and a little east of south to its junction with the Buttahatchie at the southern boundary of the county. Below the junction of the two forks in the northern part of the county the river describes a series of large bends and several hairpin loops; it is extremely crooked in detail, but in general follows the strike of the rock beds near the contact of the typical lower Eutaw formation with the Tombigbee sand member, cutting its channel in the Tombigbee sand for the most part. The average fall is between 2.0 and 2.5 feet to the mile. The largest tributary from the west is Old Town Creek, or West Fork of Tombigbee River, but others are Matubby Creek, which has numerous branches; James Creek; and in the southwestern corner of the county several southward-flowing branches of Town Creek which joins the river in Clay County. All these streams trend southeast in general. From the east the Tombigbee receives Buttahatchie River, McKinley Creek, Halfway Creek, and Weaver Creek, besides numerous smaller streams. The Buttahatchie rises in Alabama, enters Monroe County in Section 33, Township 13 South, Range 16 West, a little north of Gattman, and flows in general west, southwest, south, and southwest. It forms the Monroe County-Lowndes County boundary for 15 miles or so. Although somewhat winding, its course is noticeably less meandering than that of the Tombigbee, a condition due chiefly to the higher gradient of the Buttahatchie. The chief tributary of Buttahatchie River is Sipsey Creek, which joins its main about 1.5 miles southeast of Greenwood Springs and 0.3 mile south of Mississippi State Highway 6. Sipsey Creek and its largest tributary, Splunge Creek, drain the northeastern corner of the county.

Some peculiarities of stream pattern are noticeable. On the east side of the river the tributaries flow in general almost west or only a little south of west, and join the river at a high angle; on the west side they take a south by east or a sharp southeast course and make a much lower angle with the river. Possibly these features are due in part to the down-dip lateral cutting of the Tombigbee.

The volume of water carried by the stream channels varies widely. The average annual rainfall is about 47 inches.[2] East of the Tombigbee a large proportion of this precipitation is absorbed by the sands and gravels, but west of the river the run-off is greater. Hard downpours of rain are not uncommon, flooding the stream channels, but the water runs off rapidly and unless the rains are continuous or essentially so for a considerable time, many of the smaller stream channels are dry for weeks. The Sipsey and the Buttahatchie have their beginnings in the sand and gravel country of northwestern Alabama, where springs are numerous; besides, their channels are cut below the lowest water-table of the region; for these reasons they flow continuously. The same conditions affect other sizeable eastern tributaries of the Tombigbee.

STRATIGRAPHY

The exposed rocks in Monroe County range from the Tuscaloosa formation of the Upper Cretaceous to the Recent, except for the Eocene, Oligocene, Miocene, and Pliocene, which, if ever deposited, have been worn away by erosion.

GENERALIZED SECTION OF EXPOSED ROCKS [4, 5]

Psychozoic group — Feet

Holocene system

Recent formation

Mantle rock, including subsoil and soil, in situ; talus, and colluvium, in the form of accumulations at the foot of slopes; alluvium, as flood-plains, alluvial fans, or channel forms; all composed of sand, gravel, silt, and clay in various proportions and relationships .... 50 to 60

Unconformity

Cenozoic group

Pleistocene system

Terrace formations

Terrace loams, sands, gravels, and clays: The sands are fine, gray or deep-red; the gravel is abundant, chiefly chert, in beds or in lenses and stringers in the sand. The Pleistocene materials are generally in the form of terraces which rest unconformably on the Cretaceous formations .... 0 to 25

Pliocene system—? Possibly some of the materials included in the Pleistocene are of Pliocene age

Great unconformity

Mesozoic group

Cretaceous system

Gulf series

Selma formation

Marine chalk, soft, argillaceous, sandy, and beds of almost pure sand, sandstone, and limestone; phosphatic beds locally. The impure chalk is dark bluish-gray where fresh, but dries to light-gray and white or yellowish; outcrops are glaring white. The chalk is massive or bedded, and jointed. The Arcola member, 220 to 240 feet above the base of the formation, is pure limestone. Some beds of the Selma are very fossiliferous 350

Eutaw formation

The Eutaw formation consists of two units: the typical Eutaw below, and the Tombigbee member above. The Eutaw proper is dominantly sand, locally cemented into masses of ferruginous sandstone, but clay layers and laminae, commonly lignitic, are interbedded with the sand. Small lenses and stringers of small pebbles are a part of the formation, also, and the basal zone may be chiefly cross-bedded glauconitic sand cemented in places into hard tubular and corrugated sandstone, and associated with a bed of small subangular chert gravel. Some bentonite deposits are included, also. The Lower Eutaw grades upwards into the Tombigbee sand, which is massive, glauconitic, and somewhat calcareous, and includes irregular indurated layers. The typical Eutaw is very sparingly fossiliferous, but the upper part of the Tombigbee member contains many fossils 300-350

Unconformity

Tuscaloosa formation

Sand, sandstone, clay, clay shale, gravel, conglomerate, lignite: The sand, which is the dominant component of the Tuscaloosa formation in Monroe County, is generally fine, commonly ferruginous and micaceous; gray to greenish-gray or variegated, and locally cemented to sandstone. It is aggregated as thinly laminated beds or lenses, or disseminated through the other materials. The clays are compact, commonly dark-gray or brown and lignitic in the lower part of the formation, lighter colored in the upper part, mostly somewhat sandy, but some very pure; they are in the form of beds or lenses. Some bentonite is part of the uppermost Tuscaloosa. The clay shales are commonly dark, compact, sandy beds. The gravel consists of light-colored chert pebbles, in irregular accumulations chiefly in the lower part of the formation; locally and at various levels it is cemented into conglomerate. The lignite is very subordinate, and in general impure. The Tuscaloosa is characterized by irregular structure 600

Great unconformity

THE TUSCALOOSA FORMATION

The Tuscaloosa,[4 5 7] oldest of the formations which crop out in Monroe County, lies unconformably on the Paleozoic beds, and dips west by south at an average angle said to be 30 to 32 feet a mile[4], although the dip varies and may range from 20 to 32 feet a mile or even more widely because of local flexures or other irregularities of structure. Due to the irregularity of the old Paleozoic surface on which it rests, the lack of uniformity of original deposition of the component materials, and differential erosion since its accumulation, the Tuscaloosa varies considerably in thickness from place to place.

Stephenson and Monroe[5] state that the greatest thickness recorded in Mississippi was about 600 feet, in the P. J. MacAlpine Rye No. 1 well, southeastern Monroe County, and that thicknesses of 193 feet, 133 feet, and 167 feet were found in the Cowart well, the city well at Amory, and the Bourland well, respectively. Approximate thicknesses penetrated in other wells are indicated in Plate 4. Well records show that the formation thickens southwards. The outcrop belt of the Tuscaloosa borders on the west and southwest the Paleozoic upland, and in Mississippi varies in width between 5 and 15 miles;[7] its maximum width in Monroe County is about 13 miles according to Stephenson and Monroe, who show it on their map extending westwards along the northern border of the county to Tombigbee River.[5]

The Tuscaloosa formation is made up of sand, gravel, ferruginous sandstone, conglomerate, clay, clay shale, lignite, clay ironstone, and small percentages of other materials.

The Tuscaloosa sand is commonly coarse to fine, loose, almost invariably ferruginous, and of variegated colors: light drab and gray to dark green or gray, deep red, yellow, or banded and splotched with a confusion of colors. Locally it has been cemented into ferruginous sandstone. Mica is very common, and in some layers abundant; marcasite and carbonized or lignitized wood are mixed with the sand in places.

Gravel is very abundant in the formation as a whole. It consists very largely of angular to subangular light-colored coarse chert, probably derived chiefly from the Mississippian strata. Quartz pebbles are few, small, and smoothly rounded. The gravel is chiefly in the basal beds near the basement rocks, probably most of it in the basal 175 feet of the formation, but in some places it is well represented in the middle parts of the formation. In many places, and at various levels, the gravel has been cemented into an extremely tenacious conglomerate, the cementing material being iron oxide, or silica, or both. Gravel does not have such a prominent place in the Tuscaloosa of Monroe County; the gravel beds are chiefly in the extreme eastern and northeastern parts, especially east of Splunge Creek and Sipsey Creek.[5]

The Tuscaloosa clays are of varying degrees of purity and of several colors. In Mississippi the clays of the lower part of the formation are compact, dark gray, brown, and lignitic, in thin beds; those of the upper part are of lighter color, in general: they may show white, pink, red, yellow, mottled, or other solid colors or combinations of colors. Much of this upper clay is sufficiently pure for use in the manufacture of stoneware and pottery; it may be low in iron and contains only a very little fine sand. The lignitic clays may contain leaf impressions. Beds of very compact sandy clays, particularly in the lower part of the formation, may be considered clay shale. In some places seams of clay ironstone have been formed by cementation of the clay along certain horizons by iron oxide precipitated from circulating ground waters. Some bentonite may be in the uppermost strata of the Tuscaloosa.[5]

The lignite of the Tuscaloosa is not of great consequence: it is present as well-defined seams no more than 2 to 3 feet in thickness, or as scattered lignitized logs and small pieces. Much of it is impure; it may be dense and black like coal, and contain a little yellowish-brown fossil resin and in places a noticeable content of iron sulphide, chiefly marcasite.

None of the types of rock material described from the Tuscaloosa is confined to any certain part of the formation, or has any fixed relation to any one or other of the other kinds of materials. Many lenses or beds of clay contain considerable sand, and even pebbles; the predominantly sand units may, and in most cases do, contain clay or a little gravel; in fact, in the sand strata clay lenses and discontinuous clay beds are numerous, and in places much chert gravel is associated with the sand. Likewise, the gravel may hold a mixture of sand and clay, and includes lenses or lentils of sand. Beds or lenses of almost pure clay, or sand, or gravel, are present, but any one of these may be low down in the formation, or up towards the top, or may occupy an intermediate position; and the clay may be interbedded with gravel, or sand, or enclosed by both. Several lenses or lentils of white clay were found between layers of gravel or ferruginous sandstone.[7]

The irregularity of the structure of the Tuscaloosa formation is one of its most striking characteristics. Cross-bedding of sand and gravel is the rule; contemporaneous erosion surfaces are common; a body of any kind of material may pass laterally into another kind in a short distance—for example, there are many cases of lateral gradation from clay to sand in a few rods. Consolidated sheets or seams may cut the mass of the unconsolidated rock material at almost any angle, and, as has been said, the different units may have almost any sort of relation to each other—if there is any system in their arrangement it is not conspicuous. Perhaps in general the formation is more sandy and gravelly towards the base and more clayey above. In short, a conspicuous feature of the Tuscaloosa seems to be heterogeneity of materials and of arrangement of materials, both of the units themselves with relation to each other, and of the parts of each unit. This seems to be evidence that the formation was deposited from fresh waters, probably much of it in the form of huge alluvial fans, piedmont alluvial plains, and stream plains on low lands bordering the coast or on wide stream flats, or, farther south and southwest, in the margin of the shallow sea. Naturally both large and small streams carried the rock waste, and these were at times in floods, swift and turbulent, and at other times small and slow moving. Alternating swamp and shallow water conditions no doubt existed on the deposition areas—bays, lagoons, marshes, and the deltas of debouching streams.

Stephenson and Monroe[4, 5] state that the Tuscaloosa deposits were laid down in a sea which transgressed from west-central Alabama northwestwards through Mississippi. Apparently they do not recognize any land or fresh-water part of the formation.

In Monroe County the Tuscaloosa outcrop belt does not extend farther westwards than the western limit of Range 17 West, except along the northern boundary of the county. This north-south strip includes only about one-fifth of the total width of the Tuscaloosa outcrop belt in this latitude, which means that the Monroe County Tuscaloosa is only the upper part of the formation. And even this part shows only along and near the larger valleys—the valleys of Buttahatchie River, Sipsey Creek, Splunge Creek, and Weaver Creek. It appears that the lithology of the Tuscaloosa of Monroe County differs somewhat from that of the formation farther east and farther north, chiefly in the predominance of the sand and clay, particularly the sand, over the gravel. Stephenson and Monroe[5] state: "The formation consists in general of thinly laminated very fine micaceous sand and light-colored clay, but east of Sipsey Creek some poorly assorted gravel crops out beneath the sand and clay." They mention also "a fairly persistent bed of bentonite . . . near the top of the formation," and "lenses and layers of lignite." The Charles Cox bentonite (Sec. 10, T. 12 S., R. 17 W.) and a deposit 1.5 miles north of Greenwood Springs are assigned to the Tuscaloosa, although the admission is made that the stratigraphic posi-

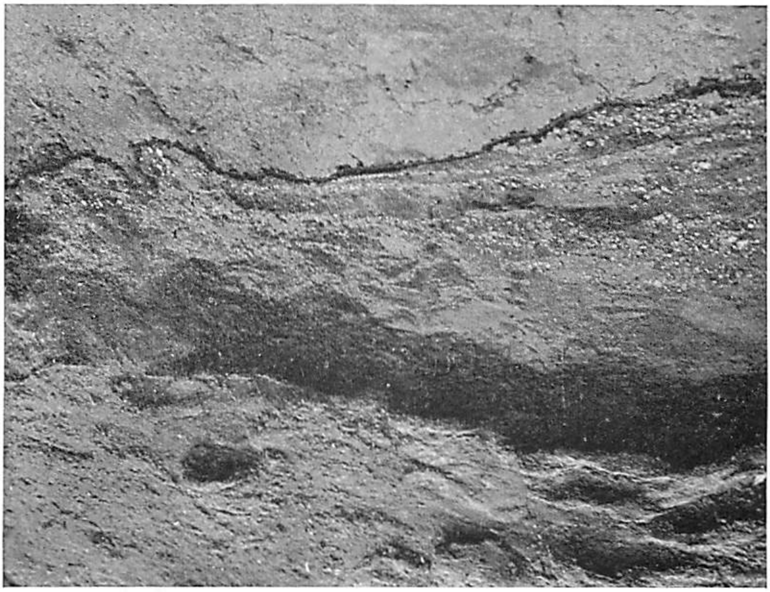

Figure 2.—Tuscaloosa-Eutaw unconformable contact, west wall of Buttahatchie River valley, on a local road about 10 miles southeast of Aberdeen. Photo by F. F. Mellen, March 30, 1937.

tion of the Greenwood Springs deposit with respect to the Tuscaloosa-Eutaw contact was not determined.

The same writers[5] refer to two exposures of the Tuscaloosa-Eutaw unconformable contact in Monroe County: Johnsons Hill (NW. 1/4, Sec. 1, T. 12 S., R. 9 E.) 4.5 miles east of Smithville; and a local road on the southeastward-facing slope of Buttahatchie River valley, about 10 miles southeast of Aberdeen (Figure 2). Tuscaloosa outcrops below the contact were observed on the lower slopes of the hills west of Buttahatchie River in the southeastern part of the county.

A description of the Johnsons Hill section, as determined by the present survey, follows:

Section of North Wall of Cut For The Smithville-Pikeville Road, West Slope of Johnsons Hill, Sec. 2, T. 11 S., R. 9 E.

	Feet	Feet
Psychozoic group, Holocene system		
Recent series and formation		1.5
Mantle rock, including gray and brown sandy loam soil and brown clayey sand subsoil, to summit of steeper slope	1.5	

Mesozoic group, Cretaceous system

Gulf series, Eutaw formation		50.0
Sand, cross-laminated red-brown micaceous; streaked with dull white or light-yellow; contains much small chert gravel and tubular ferruginous sandstone towards the base, and crusts of ferruginous standstone at various levels	50.0	
Interformational unconformity, 60 feet above the bed of the creek under the bridge at the foot of the hill		
Gulf series, Tuscaloosa formation		60.0
Clay, lignitic sandy; clay, whitish, and clay, purplish-gray: three intervals, but the individual beds were not measured	23.4	
Clay, light-blue, and sand, brown, in thin layers	5.0	
Sand, brown loosely consolidated; interlaminated with light-gray clay	1.0	
Clay, light bluish-gray sandy micaceous; containing lentils of brown sand and friable sandstone, and platy sandstone at various levels	8.0	
Sand and friable sandstone, yellow and brown fine micaceous; thinner towards the east; a lentil in a dominantly clay terrane	2.3	
Clay, light-gray jointed compacted somewhat iron-stained slightly sandy; interbedded with brown sand or platy sand rock, especially towards the base; 0.5-foot of brown sand near the middle of the interval	5.5	
Sandstone and clay: Sandstone brown friable to indurated micaceous, platy in part, interlaminated with bluish-gray silty micaceous clay	1.5	
Clay and sand laminae: Clay light-gray, interlaminated with fine brown angular micaceous sand; more clayey towards the top	3.3	
Covered, to level of creek floor under bridge	10.0	

THE EUTAW FORMATION

The Eutaw[4 5 7] is a dominantly marine shallow water formation which in Mississippi rests unconformably on the Tuscaloosa as far as has been determined. The contact zone is marked by a band of more or less lignitic and carbonaceous clay 15 to 20 feet thick, containing thin layers of glauconitic sand; the contact itself is immediately above this dark band. The Eutaw consists of two units—the lower, or typical Eutaw, and the upper, or Tombigbee sand member; the contact between the two is gradational, the transitional zone being cross-bedded and laminated clay. The lower unit of the Eutaw has a thickness of 200 to 250 feet, and the Tombigbee sand an average thickness of 100 feet or less.[5] Variation of the thickness of the Eutaw formation is shown by well records. For examples: The municipal water plant well at Amory, located below the Tombigbee sand member, passed through 220 feet of typical Eutaw beds,[4] and the Bourland No. 1 well, only a mile or so farther south, found 222 feet of Eutaw,[5] according to the logs; but of the strata penetrated by the Compress well at Aberdeen, which is located on the Tombigbee sand outcrop, only 175 feet were assigned to the Eutaw.[4] The Moses Williams water well, near Strongs, some 8 miles south by west of Aberdeen, is said to have penetrated 315 feet of Eutaw, but did not reach the bottom of the formation.[4] Thicknesses discovered by wells drilled for oil and gas are indicated by Plate 4. Many of these recorded thicknesses seem inconsistent with the rather uniform thickness commonly characteristic of a marine formation, and some of them may be erroneous, due to incorrect identification of strata. No considerable unconformity is involved, and elevation differences among the three water wells mentioned above do not exceed 31 feet. The Eutaw belt of outcrop, some 24 miles wide in Monroe County and including approximately the eastern three-fifths of the county, adjoins the Tuscaloosa belt on the west, and maintains an approximately uniform width north-south across the county.

The Eutaw is predominantly fine-grained to medium-grained micaceous glauconitic sand, but contains considerable clay, which is chiefly in the lower member. The Lower Eutaw is composed of sands interstratified with laminated layers, thin laminae, and some more massive layers of clay, most of which is dark gray to nearly black (Figure 3). Plant fragments and pieces of lignite are common in these clays. Other features are small lenses and stringers of small pebbles, especially in the lower part of the formation. A bed of small subangular chert gravel is a common feature of the base of the formation (Figure 2); almost everywhere it is associated with cross-bedded glauconitic sand, which may be cemented by limonite into hard tubular and corrugated sandstone. Fresh sands of the Eutaw may be white, but commonly are gray to greenish gray; the weathered facies are deep reddish to brownish due to the oxidation of the iron-bearing constituents, and in many places are cemented into platy layers, sandy oxidized concretions, and even huge masses of ferruginous sandstone. The Tombigbee sand member is massive glauconitic somewhat calcareous sand, some layers of which are indurated and contain concretionary masses, especially in the upper part of the member (Figure 4).

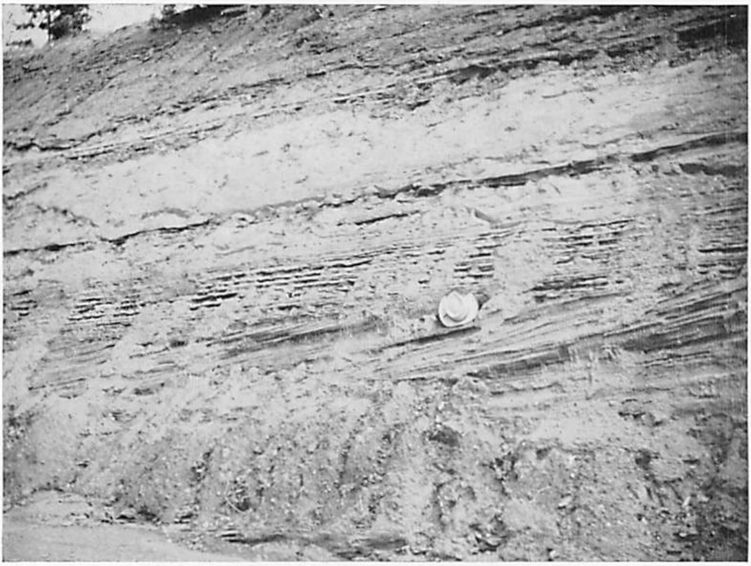

Figure 3.—Lamination and cross-lamination of Lower Eutaw beds. Face of northeast wall of cut for State Highway 6 in west wall of Buttahatchie River valley about 1 mile northwest of Greenwood Springs. August 14, 1941.

The Lower Eutaw is sparingly fossiliferous; plant fossils are noticeable in places. The upper part of the Tombigbee sand contains many fossils of marine invertebrates and vertebrates; but so far as has been determined, a large part of the member is not fossiliferous.

Aside from the dip, averaging about 30 feet to the mile[4] a little south of west in Monroe County, no larger structural features are evident, although some minor flexures may disturb the uniformity of dip; but smaller structures, such as cross-lamination and other irregularities of bedding which are so prominent in the Tuscaloosa, are common and conspicuous in the Lower Eutaw (Figure 5). Joints are rather prominent in a few places, especially in fresh outcrops; no fault traces were observed.

The characteristics referred to above—materials chiefly fine to medium micaceous glauconitic sand, containing thin clay beds, very irregular structure, consisting of lamination, cross-bedding, contemporaneous erosion surfaces, lensing—suggest deposition in shallow marine waters, where currents had considerable play; the lignite fragments indicate a deposit near a low shore, and the glauconite and the fossils of the Tombigbee sand point to deeper marine shore waters. Finely cross-bedded small irregular lenses are thought to have been formed by waves near the lower limit of their action, and the small lenses and stringers of small pebbles are believed to mark places where the present inner margin of the formation is relatively near the ancient shore line of the Eutaw sea.

The characteristics of the Eutaw formation are well illustrated in a number of places in Monroe County. Stephenson and Monroe[5] describe several sections at places separated sufficiently to be fairly representative of the entire formation. The outstanding features of the sections are: the presence of the fossil *Halymenites major* Lesquereux in the sands of the Lower Eutaw 8 miles east of Amory on the Splunge road; the Lower Eutaw-Tombigbee sand contact in two sections of the Tombigbee River channel walls near Aberdeen; the Eutaw-Selma contact in a road cut 8 miles north of Aberdeen and in a road 4 miles west of Amory and a mile and a half west of Cotton Gin Port.

The thickness of the formation (Eutaw) of Monroe County ranges from 300 to 400 feet, as determined from well logs.

Strata belonging to the Tombigbee sand member of the Eutaw formation are well exposed in a number of places along the bluffs of Tombigbee River, especially on the outsides of the numerous bends of the river, where the water has undercut the banks, causing slides and landslips which, in conjunction with the work of the river, have shaped the terrane into vertical and subvertical cliffs. These are especially conspicuous on the west side of the river, where the erosion is down dip. An excellent example is Blue Bluff[6] (Figure 4), about 0.5 mile north of Aberdeen (SE. cor. NE. 1/4, NW. 1/4, Sec. 26, T. 14 S., R. 7 E.). Blue Bluff is the wall of the river channel at the northwest end of a big hairpin bend; its summit is 115 feet above low water level of the river, and at least 70 to 75 feet of the wall is a vertical-faced cliff. At the bottom is a

Figure 4.—Blue Bluff, west wall of Tombigbee River channel about 2 miles north of Aberdeen, showing Tombigbee glauconitic sand. Contact between Lower Eutaw and Tombigbee Sand member slightly above water-level in lower right corner. Photo by F. F. Mellen, March 30, 1937.

somewhat indurated greenish sand, black to rusty on the weathered surface, tending to weather and split into thin layers similar to shale; this sand crops out just above water level for considerable distances up and down stream. This interval probably belongs to the uppermost Lower Eutaw. Immediately overlying this is a massive green sand containing protruding indurated layers and large concretions, masses and blocks of which have fallen to the base of the cliff and lie tumbled about in the sand. Some of these concretions are almost spherical, extremely tenacious, and range in size from very small up to a foot and a half in diameter. Above the massive green sand interval are at least 20 to 25 feet of laminated light-yellow sand, and above it darker yellow sand. Large fossil oyster shells (*Exogyra ponderosa* chiefly) show here and there in the vertical face of the cliff, but no definite shell layer was noted.

Another bluff of the same type as that just described is Black Bluff,[6] about 5 miles south by east of Aberdeen in a straight line, but at least 10 miles by river. The top of the bluff is here 143 feet above normal water level. The river, in making a right-angle bend, swings over against its channel bank, forming a steep bluff as at Blue Bluff and a number of other places.

THE SELMA CHALK

The Selma chalk,[4 5 7] called by earlier geologists the "Rotten Limestone," crops out as a crescent-shaped belt of which the inner

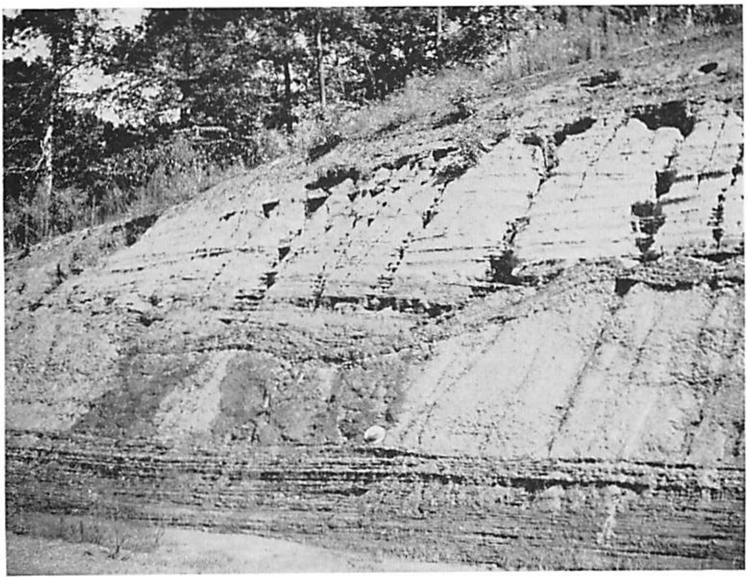

Figure 5.—Lower shaly clay below a contemporaneous erosion surface and laminated sand above it; ferruginous sandstone at the base of the sand. Face of north wall of cut for new State Highway 6, about 6 miles southeast of Amory. August 27, 1941.

edge is the Eutaw-Selma contact. This outcrop belt has a maximum width of 24 miles or more a little west of the Alabama-Mississippi state line,[5] but narrows northwards and eastwards. The formation as it was originally delimited, including the whole body of lime, has a maximum thickness of 1,000 feet more or less, and dips west, southwest, and south 30 to 32 feet a mile.[4] In Monroe County the thickness of the Selma probably is not greater than 350 feet. The formation lies unconformably on the Tombigbee sand member of the Eutaw, the contact being marked by a basal conglomerate consisting of phosphatic nodules, phosphatic molds of fossils, and oyster shells of which some were reworked from the Tombigbee sand.

The chalk varies from a soft argillaceous or sandy limestone to hard layers of nearly pure limestone; the $CaCO_3$ content ranges from 95 to 98 percent in a few places to practically nothing in oth-

Figure 6.—Gullying in fossiliferous Selma Chalk showing miniature "mesas" formed by thin indurated layer of calcareous sand (line in center foreground). Near head of tributary of Old Town Creek, 0.5 mile east of U. S. Highway 45 E. (Sec. 13, T.12 S., R.7 E.). October 13, 1941.

ers. In general the chalk of northern Mississippi is more sandy and clayey than the typical chalk farther south. Almost pure sand or sandstone is interbedded with limy sand or sandy lime here and there, and the clay content is so considerable in certain beds and in certain areas that unlined cisterns in the chalk will hold water for long periods. So slowly does the material yield up its contained water that it is considered non-water-bearing, and serves as an excellent cover for the Eutaw aquifers from which abundant water is obtained through artesian wells in the Selma area. Widely scattered in the chalk, but much more abundant in the harder layers, concretionary nodules of marcasite are common, and at least three phosphatic layers have been found. The rock is dark bluish gray in fresh exposures, but dries to light gray and white, and may be yellowed somewhat by iron on weathered exposures and along joint planes. The Selma chalk areas are featured by "bald" spots of glaring white outcrops, especially along the walls of the stream channels and on hill slopes (Figure 6). Some horizons are very fossiliferous.

Lowe states that there are three more or less distinct phases of the Selma: Sandy basal portions, highly calcareous; middle bodies of a tough, clayey, blue limestone called "blue rock," nearly impervious, which act as an artesian cover; and an upper, nearly pure limestone.[7] Lowe's classification holds only in a general way. His upper division is now considered a separate formation, the Prairie Bluff chalk.[5]

The chalk is massive of structure, commonly, but bedding is distinct in places, especially where the rock has a considerable clay or sand content, or where weathered products are removed promptly so that lithologic and hardness differences, even where slight, can be brought out, as in the faces of bluffs. Jointing is conspicuous in numbers of places, notably in the more firmly consolidated facies, and to a certain extent is noticeable in nearly all outcrops of the chalk. Along the Selma-Tertiary contact are a few small faults.

Although the Selma chalk is a relatively thick formation, it has not been subdivided except for the recognition of the uppermost 80 feet or so as the Prairie Bluff formation, and of a very pure layer or two some 200 to 265 feet above the base of the Selma as the Arcola limestone member.

That the chalk probably was deposited in a sea less than 600 feet deep or even less than 300 feet deep, is indicated by beds composed in great part of large Ostreidae shells. The lime which composes the chalk appears to have been derived chiefly from the calcareous remains of minute flagellate algae (coccolithophores) and only very subordinately from calcareous remains of foraminifera and other marine organisms.[5]

Stephenson and Monroe say of the Arcola limestone: "Within the Selma chalk, and ranging above its base from 200 feet near Mooreville to 265 feet in Noxubee County, is a persistent bed of hard fairly pure limestone a foot or more thick . . . It forms an excellent key bed and is useful in studying the geologic structure of the generally featureless chalk . . . In Mississippi the Arcola member apparently consists of only one limestone bed about a foot thick." They state that "phosphatic nodules and molds have been observed above the limestone . . . near Gibson and on a branch of Mattubby Creek, Monroe County." The Arcola limestone is underlain and overlain by the typical impure Selma chalk. The original description of this limestone apparently was written by E. A. Smith, who as quoted by Stephenson and Monroe, describes the rock as " . . . a stratum of undetermined thickness of a tolerably pure limestone of light yellow color, filled with concretionary lumps, cylinders, etc., of clay. When the clay washes out it leaves the limestone perforated in every direction, which circumstance is referred to in the name 'bored rock' ". Smith noted that the stratum had a tendency to break into large cubical blocks, and formed a rocky ridge at surface exposures. Stephenson found the Arcola to consist at Hatchs Bluff on Warrior River in Alabama of two two-foot beds separated by a two-foot bed of chalk.

In Monroe County the Selma chalk is the uppermost formation, except for the mantle of rock waste, of approximately the western third of the county. In general the chalk is very sandy and clayey. The unconformable contact with the underlying Tombigbee sand member of the Eutaw is exposed in a few places, notably in a cut for the old highway from Aberdeen to Cotton Gin Port, some 8 miles north of Aberdeen (NW. Cor. Sec. 22, T. 13 S., R. 7 E.), and in a road cut a mile and a half west of Cotton Gin Port, and 4 miles west of Amory (Sec. 9, T. 13 S., R. 7 E. ?). The Arcola limestone, according to Stephenson and Monroe, lies 220 to 240 feet above the base of the Selma in Monroe County, and trends rather irregularly north-south in the western tier of townships (Plate 1). Several outcrops are mentioned, the southernmost being in a ditch at the intersection of Mississippi Highway 8 and a north-south road 1.5 miles east of Gibson and the northernmost at the site of old Camargo (SE. 1/4, Sec. 3, T. 12 S., R. 6 E.), in the northwestern corner of the county. The same writers list seven localities where fossils are abundant.

During the survey covered by the present report a general reconnaissance over the Selma area of the county was made, and numerous outcrops visited, including those already mentioned, and others described in the parts of this report relating to agricultural limestone and cement materials.

PLEISTOCENE AND RECENT FORMATIONS

The Pleistocene system[5] and possibly the Pliocene are represented in Monroe County by terrace loams, sands, and gravels (Figure 7). In the eastern part, especially along Buttahatchie River, these materials rest unconformably on Tuscaloosa beds; in an area 5 to 7 miles wide bordering Tombigbee River on the east they lie on the Eutaw eroded surface; in a few places west of the river, they are in contact with the Selma. The cutting of the terrace plains has

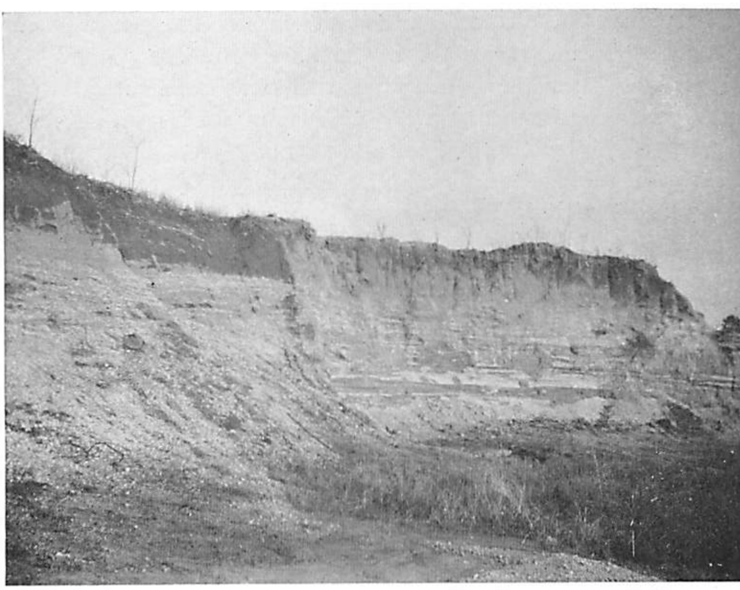

Figure 7.—Pleistocene terrace loam, sand, and gravel; 15 to 20 foot face of wall of gravel pit in second-bottom terrace of Tombigbee River about 0.5 mile west of Amory on the north side of U. S. Highway 41. December 16, 1941.

been assigned chiefly to Pleistocene and Recent times, but the terrace-forming processes may have affected this region in the Pliocene period, or even earlier. A series of terraces was formed, the highest reaching an elevation of 175 feet above the river. According to Stephenson and Monroe, at Aberdeen the top of the lowest terrace is 35 to 40 feet above low water level of the river, and the next higher plain, on which the town stands, is some 60 feet above the same datum. The uppermost interval of the lower terrace is 15 feet of Pleistocene greenish-gray and yellowish sandy clay, stratified in the lower portion; the section described is in the right bank of Tombigbee River, below the Frisco Railroad. In the section at the highway bridge south of Aberdeen the uppermost interval, considered Pleistocene alluvium, is 16 feet of fine gray sand; and in a gully some 10 miles east of Aberdeen the Pleistocene terrace deposit member is a deep-red ferruginous sand, containing stringers and small lenses of pebbles in the lower 4 feet. From these examples the thickness of the Pleistocene materials seems to range from a film up to perhaps 20 feet.

Thicknesses of Pleistocene deposits passed through by water wells of the county range from 16 to 40 feet.[4] In general the logs of the wells bored for oil and gas do not classify the strata according to geologic age; for this reason not much can be learned from them. However, the Bourland well was said to have penetrated 87 feet of Recent and Pleistocene material.[5] Obviously this figure is not conspicuously consistent with the 20-foot and 22-foot thicknesses recorded for the Pleistocene found by the Amory water wells[4] near by; probably most of it is Eutaw.

Recent deposits include soil and subsoil, described in a separate section of this report, colluvium, and stream alluvium, especially channel waste. No exact figures are available for the thickness of channel or flood-plain material along any of the main streams, but certain data at hand are of indirect value as a basis for estimates. Excavations for gravel and sand have gone to depths of at least 25 to 30 feet. As part of the survey for the proposed Tennessee River-Tombigbee River waterway, the U. S. Engineers[7a] made numerous borings along the Tombigbee, most of them located on the flood-plain or adjoining terraces. Twenty-four of these holes are in the Monroe County part of the waterway route. The elevations range from 249.4 feet to 172.8 feet above mean sea-level, and the depths from 21.0 to 62.5 feet. The logs of these borings do not indicate whether or not the bottom of the Recent or Pleistocene alluvium was reached, but they describe the materials passed through as sands, silts, gravel, and clay, the feature being an unusually high proportion of silt. The prevailing colors are tan, gray, blue, and brown. Presumably the top of the Eutaw was reached by few if any of these holes; they suggest, therefore, that the flood-plain material along the Tombigbee is not less than 50 to 60 feet thick in most places.

Along in 1923-24 all gravel was dredged out of the Tombigbee for a quarter of a mile or so in the vicinity of State Highway 6 bridge northwest of Amory, but in a comparatively short time that section of the channel had been refilled with the usual types of alluvium-gravel, sand, silt, and clay.[7b]

THE PALEOZOIC FLOOR

At the close of the Pottsville epoch of the Pennsylvanian period the Alabama-Mississippi region was land which extended farther south than it does today,[7] and from that time till the present a large part of it has remained land, affected by all the geologic processes which operate above sea-level. The broad regional uplift and the folding, faulting, and metamorphosing of the Appalachian belt which began far back in the Pennsylvanian period and continued through the Permian to a climax which closed the Paleozoic era,[8] gave the slowly widening land a relatively great elevation, and a large part of it has maintained a considerable elevation down to the present, in spite of the work of degradational forces. Lesser disturbances during post-Paleozoic time, including warping, faulting, and igneous activity, retarded the lowering of the land. Through an immensely long time, three quarters of the Pennsylvanian period, and the entire Permian, Triassic, Jurassic, and Comanchean (Lower Cretaceous) periods and the time represented by included unconformities, the terrane which is now Monroe County, Mississippi, was land, exposing the Paleozoic rocks, before the first beds of the Tuscaloosa (Upper Cretaceous) were laid down there. During this time the old rocks here and to the east were subject to deep weathering and erosion; stream systems developed, huge quantities of rock waste were shifted toward the sea, and the entire surface brought lower; the sea crept northward and spread both east and west while it was receiving debris from the land, until at the beginning of Upper Cretaceous deposition in this region the water was approaching its maximum extent. The coast-line in the Monroe County area was then somewhere east of the present Tuscaloosa-Eutaw contact, unless the subsequent Eutaw sea advanced in places beyond the farthest edge of the Tuscaloosa sea.

The Pottsville outcrop area in Alabama, at least the part of it some distance back from the edge of the Tuscaloosa, either has never been covered by younger rock or the younger rock which may have been there has been entirely removed by erosion. Probably the Pottsville of this region has been the uppermost rock unit of a land mass ever since its deposition. If so, its present topography is the final result, the end product, of all physiographic processes which have affected it since the close of Pottsville time. This surface should, then, be suggestive of the appearance of the Paleozoic floor buried beneath the Cretaceous formations of Monroe County; the buried

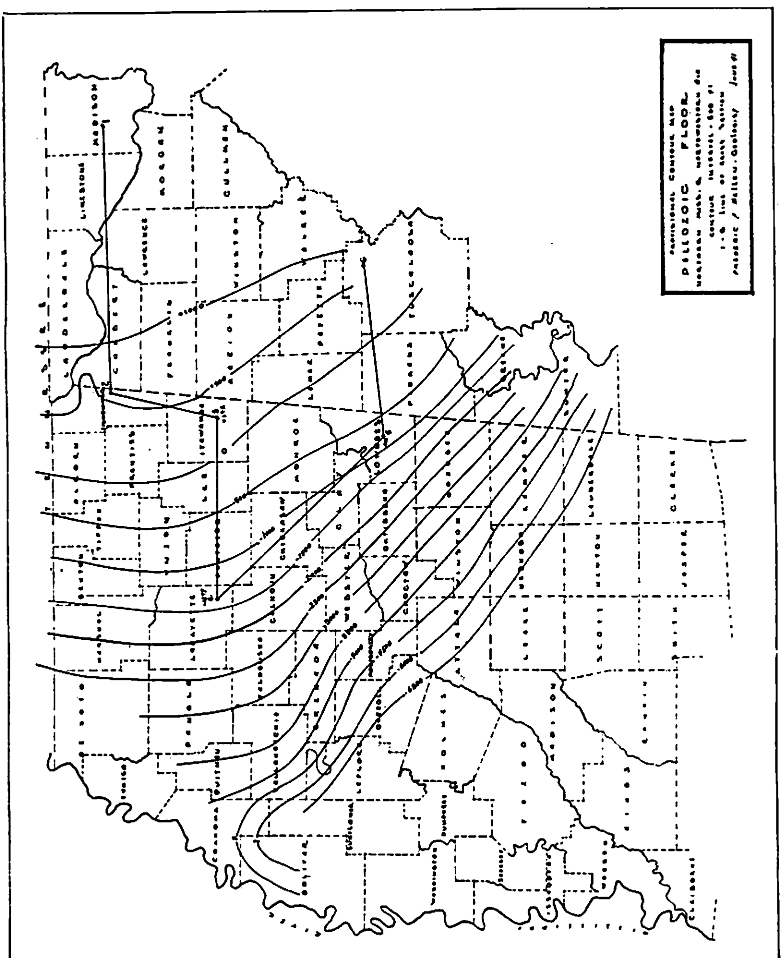

Figure 8.—Provisional contour map, Paleozoic floor, northern Mississippi and northwestern Alabama, by F. F. Mellen. June 1941.

surface might be expected to have less roughness regionally and less relief locally, perhaps, because of the essential peneplanation of the region prior to the Cretaceous submergence, and the protection of the buried part of the surface from further erosion. Unfortunately, the wells drilled to the Paleozoic rock in Monroe County are not numerous enough to afford sufficient data for an accurate picture of the old surface, and in some cases the depth to the Paleozoic was not determined accurately, and may be given at various figures, even in the same well. However, some notion of the topography of the Paleozoic floor may be obtained from the well logs (Figure 8). Most of the deep wells of the county are scattered unevenly in two groups, one within a narrow strip extending from Gattman along and north of the Frisco Railroad to Amory, the other including four wells in the southeastern corner of the county and two farther west. Surface elevation data, and the depths to Paleozoic rock as recorded in the logs of these wells, are given below:

Well	Elevation (feet)	Reported depth to Paleozoic rock (feet)	Height of Paleozoic MGL datum
Cowart No. 1	342.3	193.0	149.3
Gattman water well	280.0	311.0	- 31.0
Hall No. 1	487.8	---------	-----------
Durrett Farm No. 1	419.8	517.0	- 97.2
Carter No. 3	490.0	534.0	- 44.0
Carter No. 2	488.5	529.0	- 40.5
Carter No. 1	511.6	720.0	-208.4
Roberts No. 1	484.0	610.0	-126.0
Harris No. 1	455.0	478.0	- 23.0
Dill No. 1	374.6	---------	-----------
H. C. Crook No. 1	413.6	---------	-----------
Amory Waterworks	237.0	373.0	-136.0
Bourland No. 1	274.0	400.0	-126.0
Acker No. 1	258.1	---------	-----------
Chas. Rye No. 1	234.0	590.0	-356.0
F. L. Rye No. 1	232.4	605.0	-372.6
F. L. Rye No. 2	258.0	591.0	-333.0
Taylor No. 1	441.6	---------	-----------
C. C. Day No. 1	197.7	720.0	-522.3
Carter Oil Co., Near Muldon	283.0	1050.0	-767.0
Carter Oil Co., (Chickasaw)	300.0 ca.	1083.0	-783.0

In the three Rye wells for which data are available, the Paleozoic was reached at depths from 590 to 605 feet. In the C. C. Day No. 1, some 10 miles southwest of the Rye wells, the old rock is 720 feet beneath the surface, but the mouth of the well is from 34 to 60 feet lower than the elevations of the Rye wells. The information provided by the wells, then, seems to indicate that the southwest slope of the Paleozoic floor in southern Monroe County is 190 to 200 feet maximum in about 10 miles, that is, at the average degree of 19 to 20 feet to the mile. The table shows also that the depths to the Paleozoic in the old Carter No. 1 and the group of five wells surrounding it, if all depths are reckoned from the elevation of the Harris No. 1 (455.0 feet), range from a minimum of 478 to a maximum of 664 feet, all within a radius of less than a mile. These widely varying thicknesses of Cretaceous beds, within a small area even when the surface is considered level, would seem to indicate a locally deeply incised Paleozoic terrane. The fault which is said to cut through this area has not left any surface expression, so far as has been discovered, and possibly originated in pre-Upper Cretaceous time. Reckoned from the same datum as above, the top of the Paleozoic in F. L. Rye No. 1, about 14 miles a little east of south of the Carter No. 1 group, should be at 837 feet, indicating a maximum slope southwards of 359 feet, or about 26 feet a mile. The Bourland No. 1 well, around 7.5 miles almost due west of Carter No. 1, reached the Paleozoic at a depth variously given as 400, 580, and 675 feet, but its published elevation is 237 feet less than that of the Carter well. If 400 is the correct figure for the depth to the hard rock, the Paleozoic surface is higher at the Bourland site than at the Carter site, but if either of the other figures is accurate, the normal west slope seems to be indicated. In the Carter Oil Company Abernathy well 3 miles west of Okolona, Chickasaw County, the reported depth to the Paleozoic was 1083 feet; elevation of the mouth of the well was not given, but probably is around 300 feet. The distance between the two wells being 19 to 20 miles, a descent of the old rock surface of approximately 34 to 35 feet a mile westwards is indicated (Figure 8).

Although, as stated, insufficient data are available for a detailed picture of the upper surface of the Paleozoic underlying the Monroe County area, enough has been obtained to make clear that the old topography has its ridges and hills and valleys and flats much as the present surface has, but as a whole is more even and of greater regional relief. The lowest point reported on the old rocks in the county is 767 feet below mean Gulf level, in the Carter Oil Company well, north by west of Muldon; the highest is 149 feet above, in the Cowart well. In the interpretation of any well log and the correlation of strata penetrated by different wells, the irregularities of the Paleozoic-Mesozoic contact should be given due consideration: possibly in some cases a major role has been assigned to faulting or folding whereas the conditions could have been explained as due to an unconformity.

Stephenson and Monroe[5] estimate that the relief of the sub-Cretaceous Paleozoic surface is of the magnitude of 100 feet or more in Tishomingo County; they state also that the surface there descends westwards and southwestwards about 30 feet to the mile, but that in Lowndes County the inclination is greater than 30 feet to the mile.

STRUCTURE

The structure of the Cretaceous terrane has been discussed in the description of the Cretaceous formations but may be summarized here. The regional dip is a little south of west at rates ranging from 20 feet or less to 32 feet or more a mile, being nearly uniformly 30 feet a mile according to Stephenson and Monroe (Plate 5).[5] No other major structural feature except the unconformities mentioned has been found, but minor structural features, such as irregular bedding of several types, joints, and contemporaneous erosion surfaces, are numerous. At least one small fault has a surface expression, and other faults have been reported.

Few strata are suitable for use as key beds for the determination of structure, but William Clifford Morse as early as 1919 used the Arcola limestone in the Selma chalk as a key bed entirely across Lowndes and Clay Counties in the plane table mapping of geologic structures for local interests. In the part of the present report which deals with agricultural limestone are given some data from outcrops and test holes, from which a hint of local structure may be obtained; however, the work done in this area was insufficient to serve as a basis for any general statement as to the existence or non-existence of a structure of economic significance. The detailed determination of the Cretaceous structure in the western part of the county, using the Arcola limestone as a key bed, might be well worth while.

In the eastern part of the county the scattered bentonite deposits and the lignitic zone near the top of the Tuscaloosa are possible key beds.

The elevations (barometric) of a Lignite bed at or near the top of the Tuscaloosa, which were determined at a number of places and recorded (Plate 2), did not reveal a definite structure favorable for oil and gas accumulation. Nevertheless, they are made a part of this report, so they will be available should future work of oil geologists

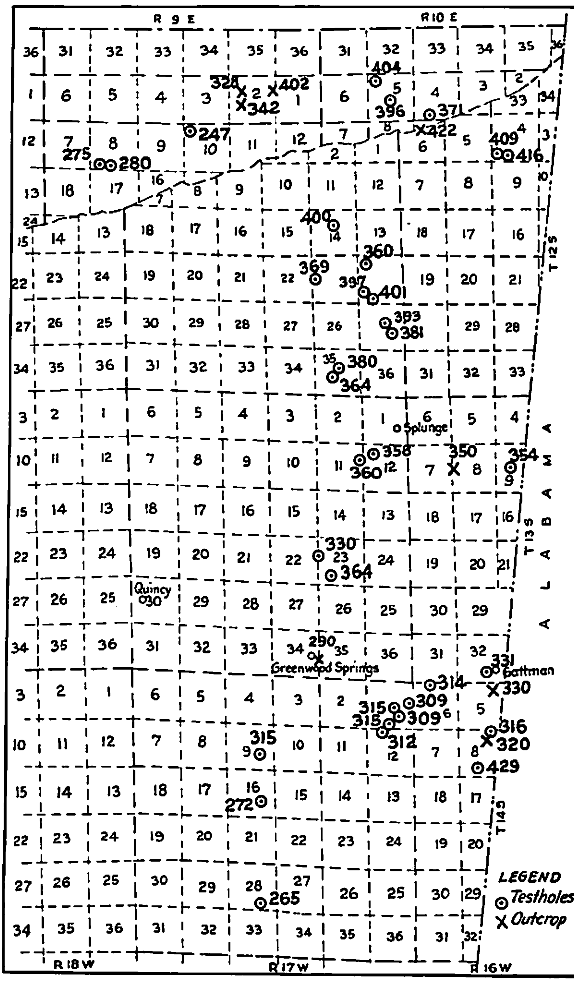

Plate 2.—Elevations of lignite zone at or a little below the Tuscaloosa-Eutaw contact.

reveal additional subsurface places where elevations of the Lignite bed could be determined.

The facts about the major structural features of the Paleozoic strata have been sought most assiduously by numbers of geologists and others, chiefly because of the close relationship of such structures to commercially important accumulations of oil and gas. Some facts have been discovered and many inferences drawn from them as to conditions where the rock is concealed—inferences which in a few cases have proved to be accurate apprehensions of the facts, but in more cases have proved to be or probably are, far from a true picture of conditions. This ratio of correct to incorrect deductions can be expected to improve as actual knowledge is increased largely through sorrowful experiences of trial and error. The one source of true information—surface conditions—can not be drawn from directly in Monroe County so far as the Paleozoic rocks are concerned, because these rocks do not crop out in the county. The second potential source of accurate information, the wells of the county, has proved in many if not in most cases of very doubtful value because of want of records or because of inaccurate records chargeable to carelessness, ignorance, or indifference, if not to deliberate deception. But due allowance being made for all the factors named, a summation of what is known or published as fact concerning the structure of the Paleozoic rocks adjacent to and underlying Monroe County is here attempted, and followed by a few interpretations and inferences for which the writer alone is responsible.

A study of outcrops in northwestern Alabama and northeastern Mississippi should give a more or less clearly defined general idea of what the stratigraphy and structure of the Paleozoic which underlies the Cretaceous of Monroe County should be. The area is less than 100 miles northwest of the northwestern border of the Appalachian mountain region where the Paleozoic strata have been compressed into long northeast-southwest folds and faulted strongly, most of the fault traces trending parallel or sub-parallel to the folds. Not once only, but several times this Appalachian belt has been the site of deformation of the beds,[8] and probably in each case the rock far to the west was affected by flexures or local faulting. The major folding along the Appalachian geosyncline was part of the great diastrophism which closed the Paleozoic era, but disturbances took place in this zone of weakness before and after that time. About the middle of the Ordovician period the far-reaching strata northwest of the present mountain belt began to feel the weight of the mountain-building forces which reached climaxes at the close of the Silurian period and late in the Paleozoic era, and finally elevated the beds into two low domes, the larger of which, the so-called Cincinnati Arch or Cincinnati Anticline, had its top south of Cincinnati, Ohio, and the smaller, the Nashville Dome, centered near Nashville, Tennessee.[8] These structures were, during later Paleozoic time, periodically submergent and emergent. In each case erosion has truncated the dome, exposing Ordovician strata in the center of the structure and younger Paleozoic beds surrounding them, all beds dipping away from the center of the uplift.

The Paleozoic outcrops of Tishomingo County, Mississippi, on the southwest flank of the Nashville Dome, give a hint of the general kind of structure to be expected in Monroe County, which is also on the southwest flank of the same major uplift at a greater distance from the center. Morse[9] found a considerable diversity of structure in these old rocks, including local dips in almost all directions, and at least four noteworthy structures of the type which could serve as oil and gas traps. Along Yellow Creek, in the northern part of the county, he found a local relatively steep east dip; the same was true in Whetstone Branch, farther south; also along Colbert Shoals Canal, northwestern Alabama, reverse dips were observed in the Carmack limestone; in the Alsobrook locality he noted a northward to northwestward dip of the Iuka to the mouth of Pennywinkle Creek and still farther north; along the north wall of Southward Pond an east dip was found, and at the northwest "corner" of the pond a north dip, which changes to a south dip southwards along the west wall. He described the four structures in some detail: the Southward (Cypress) Pond Dome, the Whetstone Branch north-south fold, the Yellow Creek Monocline, and the State Line Arch. In spite of irregularities, however, the Morse survey found the general dip of the exposed Paleozoic rocks in the northeastern corner of Mississippi to be towards the south and southwest. No evidence of faulting was discovered either in Mississippi or adjacent Alabama.

Monroe County is also west of the southwest end of the surface expression of the Appalachian folds. Thus, in its position with reference to both Nashville Dome and Appalachian folds, effects of deformation would almost certainly be present in the buried Paleozoic rocks, and possibly in the overlying Cretaceous. Minor flexures and some faults could be confidently looked for, most of which probably can not be located through expression in Tuscaloosa or Eutaw outcrops. In fact, the Pennsylvanian terrane of western Alabama bordering Monroe County shows considerable evidence of minor flexures, but contrary to the conditions which might logically be expected, these low folds commonly trend northwest-southeast rather than parallel to the Appalachian folding, and plunge southeast. The reverse dips do not exceed two degrees to three degrees in most places.[10] Some of the high points, or nodes, on these undulations should be excellent oil traps. Numerous gentle folds of this type have been developed in Colbert and Franklin Counties, including, in Franklin County, "one of the most pronounced and persistent folds in the whole of northwest Alabama, and the most favorable for testing,[10] and in Colbert a line of folding which can be traced almost entirely across the county."[10] The minor fault systems show the same northwest-southeast trend.[10] As Mellen[11] puts it, "Most of the domal or anticlinal structures in north Alabama and northeast Mississippi are faulted, the faults generally lying on the north edges of the structures and striking westerly or northwesterly. The faults appear to have had an important effect on the reservoir conditions, such as impeding the entrance of fresh water and the escape of oil."

H. D. Easton,[12] who located the first commercial gas well in Mississippi, stated, with reference to the structure of this region, that he had found four fault lines, more or less parallel, along the State Line (Mississippi-Alabama), and "approximately at right angles to the axis of the Cincinnati Arch." He expressed his belief that production would be found along each of these fault lines "and in some cases on both sides of the break." He declared further that in almost all cases the downthrow side of the fault is the south, or down-dip side, and the north, up-dip side is the upthrow side, which commonly would become more or less of a terrace. Gas, he said, was more likely on the upthrow side, oil on the downthrow side.

Specific examples of local structures in western Alabama are: A faulted dome in the vicinity of Haleyville, discovered and mapped by S. A. Hobson; a dome in the vicinity of Atwood, the site of the Atwood well which is said to have produced a heavy showing of high gravity oil; four or five small structures in Marion County, including the Johnson Ford structure in the southern part of the county; the structure on which the Gardner No. 1 well was drilled, in Lamar County; and the Fayette structure, site of the Fayette gas field, Fayette County.[13e]

Easton[12] held the opinion that the best drilling location in the Amory region is at Johnson Ford, a little south of Hamilton, Alabama, which is on his northernmost fault and shows much surface evidence of local structure.

Surface investigations, and especially the drilling of wells, have led to the discovery of some of the structural features of the buried

Paleozoic rocks of Monroe County. Easton[12a] reported the existence of a fold having a north-south axis about 6 miles east of Amory, the axis extending northwards into Itawamba County; also he reported pronounced southeast dips in shale beds which seemed to indicate a favorable high near the county line. He pointed out that the structural fold conforms roughly to the highlands between Tombigbee River on the west and Buttahatchie River on the east. Furthermore, it is said that Easton and other oil geologists who have studied the Amory field recognize the existence of a fault which strikes roughly northwest-southeast, and lies between Carter No. 1 well and Carter No. 2. It is suggested by the writer of this report, as a possibility, that the old Gordon place (Sec. 23, T. 13 S., R. 17 W.), some 5 miles southeast of the Carter wells, may be on the line of this fault. Bentonite from one small steeply-dipping deposit on the Gordon place is greenish gray, hard, heavy, and brittle, unlike any other bentonite in the county. It strongly suggests metabentonite, which could have been produced by pressure or water action, or both, on the bentonite bed during movement of rock masses along a fault-plane.

Further defining the Smithville structure, Easton[12a] noted, in addition to the fault trace outcrop at a local road bridge a little south of the Suggs pottery, in Section 34, Township 11 South, Range 9 East, northeast of Smithville (Figure 9), three other pronounced exposures: East of Splunge and north of the trace (Gaines Trace or the Chickasaw Boundary), in the eastern part of Section 8, Township 11 South, Range 10 East, a little more than 7 miles east by about 1 mile south of Smithville; just north of the center of Section 7, Township 12 South, Range 16 West, about 1.5 miles south by 0.5 mile east of the last place mentioned; and at a place about 1 mile north by 1 1/4 miles east of the Section 7 outcrop (NE. 1/4, SE. 1/4, Sec. 5, T. 12 S., R. 16 W.). He connected the four exposures, stating they outlined a fault zone which cuts across the northeast corner of the county in a direction east-west by southeast-northwest, and strongly recommended drilling on the line of the fault or south of it, preferably in Section 18, Township 12 South, Range 16 West. Easton expressed the opinion that this Splunge Creek structural area is not directly connected with the Amory field, and must stand or fall on its own merits. He claimed to have located another fault, also, of which a surface showing was at or near Blue Bluff (SE. Cor. NE. 1/4, NW. 1/4, Sec. 26 T. 14 S., R. 7 E.). This fault trace was said to strike N. 12° E. and possibly connect with the Amory fault in a gravel pit northwest of Amory (SE. Cor., Sec. 30, T. 12 S., R. 8 E.).[13a]

In brief, Easton[12] thought of the so-called Amory structure as a fault line or fault zone lying somewhat northwest-southeast and crossing the area from Amory to Gattman. On this structure he suggested three locations as favorable drilling sites: Center, NE. 1/4, SE. 1/4, Sec. 12, T. 13 S., R. 18 W., west of Carter No. 1; Center, NW. 1/4, NW. 1/4, Sec. 17, T. 13 S., R. 17 W., east of Harris No. 1; and Center, NW. 1/4, NW. 1/4, Sec. 18, T. 13 S., R. 17 W., west of Harris No. 1.

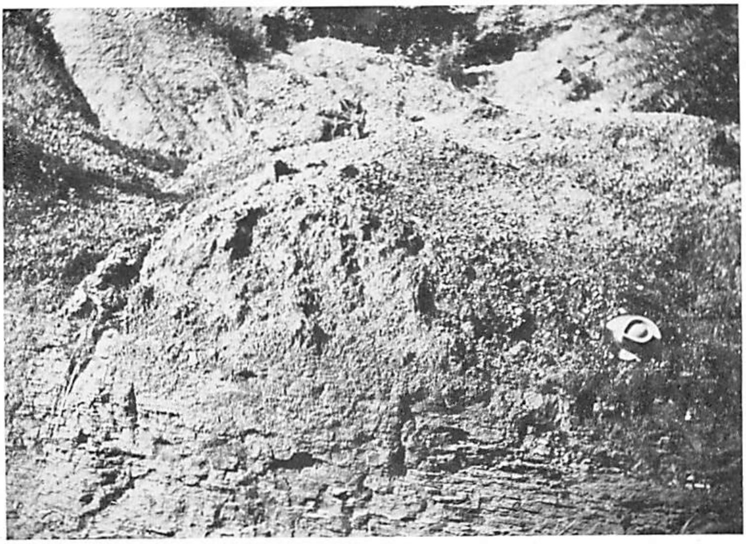

Figure 9.—Faulted Tuscaloosa beds in tributary of Bull Mountain Creek, Sec. 34, T.11 S., R.9 E., 3 miles northeast of Smithville, at a local road bridge a short distance south of the Suggs pottery. July 9, 1942.

Mr. S. A. Hobson, geologist of Haleyville, Alabama, is said to have discovered a structure in the neighborhood of Gattman, on the state line, and another between the Carter No. 1 and the F. L. Rye No. 1 wells, but no data relating to them are at hand.

The evidences of structure obtained from wells are somewhat meager, but could be much more considerable if accurate correlation could be made among the deep wells of the county. The well data relating to structure may be briefly stated. One example of probably accurate correlation may have given a clue to structural conditions in the Amory field and westwards. Butts[13b] found the interval 1810 to 1815 feet in the Bourland No. 1 well to contain fossils identical with those of the rock at 2200 feet in the Carter No. 1 well. The elevation of the Bourland well is given as 274.0 feet (D. F.), and of the Carter as 511.6 feet. The correlation of the two intervals could mean, then, that the strata dip east by south 152 feet in about 8 miles, but such an interpretation would not necessarily be correct, because the fossils in question (ostracode, bryozoan, crinoid stem plates) have a wide stratigraphic range (vertical) and the containing beds may not maintain a uniform thickness. Besides, the elevation published for Carter No. 1 is at least questionable. The original log gave the elevation of the mouth of the well as 448.0 feet (barometer), and a barometer reading by the writer of the present report showed only 400.0 feet. Relative elevations of other points, also, cast doubt on the accuracy of the 511.6-foot figure. If the correct elevation is 400.0 feet, and the correlation of the beds is warranted, obviously the eastward dip is 264 feet, or 33 feet to the mile; if the well elevation is 448.0 feet, the east dip is 216 feet, or 27 feet to the mile.

C. D. Fletcher[13c] did not entirely agree with Butts as to the age of the rock penetrated by the Bourland well, but did agree with him concerning the structure, expressing the opinion that the well was located on a pronounced nose. Fletcher thought the Carter sand should have been reached in the Bourland well at 2070 feet; Butts believed it should lie at 2080[13b] but possibly both based their opinions on a log of the Carter No. 1 well showing a depth of 2470 feet instead of the corrected depth, 2412. Easton also stated that the Bourland well was very high, much higher in formations than the Carter wells, and should produce.[13d] It was suggested, however, that the location might have been too far down the slope of the structure.

Some features of the relation of the location of wells to structures may be discussed briefly. Dill No. 1 probably was off structure; it went into salt water. Hall No. 1 was, in the opinion of some geologists, located on the wrong side of a large northwest-southeast fault; the same conclusion was asserted concerning Carter No. 2, which was said to have reached the fault plane on the downthrow side. Carter No. 3 was reported to have been located favorably in relation to structure. The Durrett Farm No. 1 was said to have been located either in a syncline or on the wrong side of the fault; it found plenty of salt water. Cowart No. 1 failed to produce for a similar reason. According to Easton, who made the location, it was too close to the Smithville fault. His later judgment was that a better location would be farther east, preferably in Section 6, Township 12 South, Range 16 West, east of Splunge Creek. Evidence of block faulting was found in the Charles Rye No. 1, and both F. L. Rye No. 2 and Willard Rye No. 1

were dry holes, whereas F. L. Rye No. 1 was a fairly good gasser, all because of peculiar faulted structure. The producing well appears to have been located between two fault planes, one striking somewhere near east-west and the other north-south or northwest-southeast in general, and only a short distance from their intersection. Of the three other Rye wells, one was south of the producer, one north, and the third east. Not only did none of the three get any production, but the sequence of strata in all three was different from that in F. L. Rye No. 1. A story was told that the site originally chosen for the first well by the geologist for Natural Gas and Fuel Corporation was on the west side of Buttahatchie River, but that, because of high water which covered that site, the well was drilled on the east side of the river which was not flooded at that time. If such scant respect was accorded his geology, the geologist can hardly be blamed for "washing his hands" of the whole affair, as he is said to have done.

Summarizing, it may be said that the existence in the Paleozoic rocks of Monroe County of certain structural features which have a direct relationship to the accumulation of oil and gas seems to have been fairly well established. These features are: at least one northeast-southwest low-angle flexure, and probably two; three northwest-southeast or east-west faults, and probably others; subordinate anticlinal ridges oriented similarly to the faults. Jillson[14] assigns a rather important role to the so-called Cincinnati Arch in the accumulation of oil and gas, not only in Ohio, Indiana, Kentucky, and Tennessee, but also in western Alabama and northeastern Mississippi. He states that the Amory field is "located close to if not exactly upon the crest of the Cincinnati arch," which in this region, "is rapidly plunging along an axial line to the south 45 degrees west." That the axis of the broad low arch, if it is an arch, trends southwestwards through Kentucky and into Tennessee, seems pretty well established from outcrops; but the structure has no surface expression far south of central Tennessee. A prolongation of the axial line from this area passes across northwestern Alabama and into eastern Mississippi, as Jillson shows on his map; but just what, if any, significance this circumstance has in relation to oil and gas accumulation in northeastern Mississippi has never been made clear. The "arch" is extremely low angled, even where it is most pronounced, and inasmuch as it plunges towards the southwest and presumably dies out in that direction within a relatively short distance, it is probably a very shallow flexure in Monroe County. Besides, not all authorities agree that the structure is anticlinal. Moore,[8] as already cited, recognizes in this eastern interior region not one major anticlinal structure, but two great domal structures, the Cincinnati Dome and the Nashville Dome. Obviously, if Monroe County lies far down the southwest flank of a dome, the regional dip of the Paleozoic strata should be southwest and south, and not northwest and southeast away from the axis of a great buried anticline. The present writer holds the opinion that such facts as have been discovered concerning the Paleozoic structure in Monroe County tend to support the concept that relatively small northwest-southeast faulted flexures, or possibly faulted domes, have influenced oil and gas concentration far more than any great northeast-southwest anticline, and he believes the time has come to discontinue the use of he term "Cincinnati Arch" or "Cincinnati Anticline" as a conjurer's phrase in oil and gas prospecting in northeastern Mississippi. The geologic data do not indicate any one great favorable structure, from which enormous production is possible, but perhaps several smaller traps some of which may be potential producers on a small scale.

GEOLOGIC HISTORY

The part of the geologic history of Monroe County which can be read from the land surface begins some time during the Cretaceous period. In general it is a story of the operation of quiet geologic and biologic processes through an immensely long stretch of years—years which should, perhaps, be numbered by millions. The Paleozoic era closed when the solid land had risen and pushed back the invading sea to it rightful borders, and the Mesozoic era began with the initiation of the sea's counter attack in their world-old warfare. Inch by inch, foot by foot, a little here, more there, the water again encroached upon the old land, assisted by a ceaseless air offensive which wore down the solid rock defenses and delivered the debris to the advancing waves as spoils of war. Farther and farther towards the north and northwest the front of the tide pressed as the land wall crumbled and went under, until the area which is now Monroe County, where for so many thousands of years the atmosphere had wasted the land and the running water had carried it away, was submerged and became the base for further marine aggression. But the tide of battle turned; the strand line was forced back far to the south and southwest, and the ramparts rebuilt in the reconquered territory. This advance and retreat of the shallow sea constituted the Tuscaloosa campaign of the war—the Tuscaloosa age, in geologic terms. It was only an episode in the never-ending struggle between the sea and the land, a conflict in which the coast-line is the battle-line. The next episode, the Eutaw and Selma phase of the war, followed immediately. The sea regained the initiative and slowly pushed the strand line eastwards to beyond the present Mississippi-Alabama state line before it was halted; and there its front remained static except for minor fluctuations, for a very long time while waste from the old Tuscaloosa land accumulated off shore, and farther out the remains of marine organisms accumulated on the sea floor among the sand, silt, and clay, or formed layers of almost pure lime where clastic sedimentation was lacking. Indeed, the biologic aspect of the history of the region came to overshadow the physical aspect; the development of marine life became the dominant feature. Nevertheless, during this age the quiet was disturbed from time to time by volcanic activity in nearby regions, and by minor crustal movements which shallowed the sea in places.

ECONOMIC GEOLOGY

OIL AND GAS

The rather long story of prospecting for oil and gas in Monroe county can be summarized only in this report.* For many years prior to the drilling of the first well a few citizens of the county, notably the late Mr. Charles L. Tubb of Amory, had shown a keen interest in obtaining an answer to the question whether or not oil or gas, or both, was present in commercial quantities in Monroe County or adjoining counties. In fact, Mr. Tubb has been referred to as "the one person primarily responsible for the oil development in the Amory field."[13e] Largely through his efforts, the Amory Petroleum Company, composed of local people, was organized in 1926, and engaged H. D. Easton, of Shreveport, Louisiana, to study the geology of the territory and recommend a location for the company's first well. Mr. Easton[12a] seems to have at first recommended the west side of Section 18, Township 13 South, Range 17 West, about 3 miles south by 6 miles east of Amory and 2 miles north of Quincy; but the site finally chosen was on the "Uncle Bony" Carter property (SW. 1/4, SE. 1/4, Sec. 7, T. 13 S., R. 17 W.), 855 feet north and 50 feet east of the southwest corner, 3 miles south and 6 miles east of Amory. The Bony Carter No. 1 well, commonly referred to simply as Carter No. 1, was begun February 15 or 16, 1926, and on October 5 or 6,

*Data for summary of history of wells were drawn from many sources: well logs, letters, published items, oral communications, and so on. Especially worthy of specific mention is a resume dated May 13, 1935, by F. P. Borden, Secretary of the Amory Petroleum Corporation.

1926, at a depth of 2404 feet, came in as a gasser, the first commercial gas well of Mississippi. Drilling was continued to a total depth of 2412 feet. Statements of the volume of the original flow varied greatly: figures of 4,568,000, 4,800,000, 5,000,000, and 5,600,000 cubic

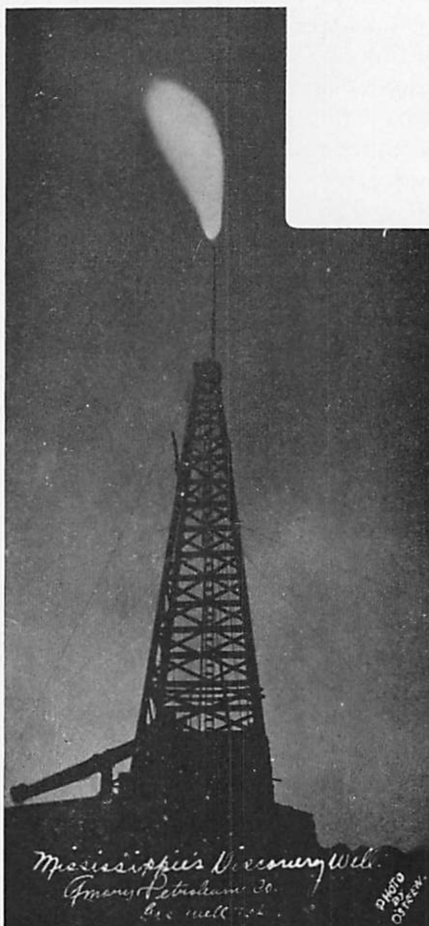

Figure 10.—Bony Carter No. 1 gas well, Sec. 7, T13 S., R.17 W. Gas burning at top of derrick. Photo by O'Steen. 1926.

feet of dry gas a day were mentioned; probably a compromise figure of 5,000,000 would be sufficiently accurate. The original pressure was said to be 680 pounds. Two years after the well came in its capacity was estimated at 8,000,000 cubic feet; and during tests made May 20, 1930, the gauge (Pitot tube) indicated a maximum flow of 6,500,-

000 to 6,600,000 cubic feet. For 93 days following the date the gas was struck, the well was allowed to flow wide open through a 6 5/8 inch casing. A short time after the well blew in the gas was fired at the top of the derrick, and for several weeks burned like a great torch, visible for many miles (Figure 10). The total gas thus wasted was estimated at 500,000,000 to 540,000,000 cubic feet.[13j] Later the well was controlled and much of the gas piped to Amory for domestic use; some was used as fuel in the boilers of the engines which powered the machinery in the drilling of other wells, for examples, the Dill No. 1 and the Hall No. 1.

The discovery well produced steadily but with diminishing pressure till the end of 1937. In March, 1927, when the well was put on the gas line, its pressure was 670 pounds.[13j] On January 4, 1938, the gas company took Carter No. 1 off their line, because pressure and volume had been so much reduced: for a considerable period the pressure had gradually dropped and the well was making only 200,000 cubic feet daily, all of which was used in Amory. This dying out of production from the discovery well perhaps should not be wondered at, because the magnetometer gave the area but 200 acres for production.[15]

An analysis of gas from Bony Carter No. 1 well, by the U. S. Department of Commerce Bureau of Mines Cryogenic Laboratory of the Amarillo, Texas, Helium Plant (C. C. Anderson, Associate Chemist of Field Survey Section) found the composition of the gas to be: Carbon dioxide, 0.15; Oxygen, 0.08; Methane, 96.92; Ethane, 1.41; Nitrogen, 1.32; Helium, 0.12.[13f]

Immediately following the completion of the discovery well, several other wells were started, and these were followed by others. To date twenty or more wells have been drilled for oil or gas in Monroe County, and a number of others in nearby Alabama and in Mississippi counties which border Monroe. The Monroe County wells will be discussed briefly, in chronological order as far as practicable.

The Amory Petroleum Company Hall No. 1, referred to also as Amory Petroleum Company No. 2 (About 850 feet north and 200 feet west, SE. 1/4, SW. 1/4, Sec. 8, T. 13 S., R. 17 W.), about 1.1 miles east of Carter No. 1, was begun some time late in 1926 or early in 1927 (one statement says December 6, 1926, another February 1, 1927) and finally abandoned some time in December, 1928. It seems that the location chosen by the company's geologist was for some reason not adopted. The well had a rather hectic history. It was started with a rotary outfit and 12 1/2-inch casing was set at 645 feet; cable tools were used for the deeper drilling. Trustworthy reports had it that at a depth of around 2400 feet an excellent showing of oil was obtained, but the driller failed to handle the situation wisely, with the result that a new bit and part of a drill stem, with accessories, were lost in the hole, and a 13 months' fishing job began. A rotary rig was then tried in the same hole, the lost tools sidetracked, and 6 5/8-inch casing set at 2395 feet, but this only complicated matters. Mechanical difficulties went from bad to worse, until finally the well was temporarily abandoned. Some time later, Mr. P. J. MacAlpine, local drilling contractor, was engaged to clean out the hole and shoot the oil sand. He removed some obstructions and cleaned out the original well down to the tools left there by the first driller. Decision was made by the directors of the undertaking to shoot the well while the lost tools were still in the hole. Probably largely because of these obstacles, the charge was exploded at least 15 feet above the oil sand, with the result that the well was bridged at the top of the old drill stem. This bridge was never broken, and the well was finally abandoned. The opinion has been expressed by people who were present when the work was being done on this well, and by some who had a part in the work, that 40 to 50 feet of oil are standing in the hole today, and that a well could be brought in there or in the immediate vicinity, especially if drilled at the location first made by the geologist. Even the total depth of the hole is a matter of controversy. A statement giving the total depth as 3045 feet was published, but the vertical depth probably is considerably less than that; yet reports on cuttings to a depth of 3045 feet are available, except for a few gaps. Reports were current that several showings of oil and gas were encountered, including rainbows of oil, and at the bottom a flow sufficient to cover the slush pit; in fact, the well was said to have produced at least half a million cubic feet of gas and several gallons of oil. Samples of the oil were collected, and an analysis of one small sample showed: Specific gravity, 30.4 Baume; gasoline, 20.7 percent; kerosene, 12.2 percent; distillate, 13.9 percent. The company which made the analysis added the following statement: "This represents 45 percent of light oil in your crude which is very good. The remaining 52 percent no doubt contains considerable gasoil, but we are unable to make this determination on account of the small size of the sample. The remaining 52 percent of residue from this crude shows a cold test of 65 indicating a heavy paraffin content."[13g]

The Buffalo Oil Company H. C. Crook No. 1 (Sec. 4, T. 13 S., R. 18 W.), on the H. C. Crook farm, was begun January 10, 1927, and abandoned in April or May, 1927, at a depth around 700 feet. This well was known also as Buffalo Oil and Gas Company No. 1, and sometimes as the Hatley well, but should be distinguished from P. J. MacAlpine H. C. Crook well, known also as the Hatley well. This later well was in reality a deepening of the old Buffalo well by P. J. MacAlpine in 1935; it had a good gas showing at 2502 feet, according to reports.

The Quincy Oil Company Durrett Farm No. 1, or Durrett No. 1, (Sec. 29, T. 13 S., R. 17 W., near the center of the NE. 1/4, NE. 1/4) on the T. F. Durrett farm near Quincy, was begun February 7, 1927, and was completed to a depth of 3075 feet May 7, 1927. Salt water was reported at 1912 feet and 1958 feet, "enough to drill with" at 2462 feet, and enough to fill the hole at 3065 feet. A showing of oil was claimed at 2353 feet, and gas shows were noted at 3040 to 3045 feet.

Dill No. 1, of the Amory Petroleum Company, referred to also as Amory Petroleum Company No. 3, located about 1.1 miles west of Carter No. 1 (Sec. 12, T. 13 S., R. 18 W., 151 feet south, 48 feet west of NE. Cor. SW. 1/4, SW. 1/4), did not produce in commercial quantities. For some reason the location made by Easton for this well was not adopted. Drilling was started February 17, 1927, and at about 2230-40? feet the tools were lost and could not be recovered, so the rig was dismantled and the well abandoned after being plugged. Later P. J. MacAlpine re-opened it and deepened it to 2463 feet. The account given by the driller of the deepening of the well under MacAlpine's direction was terse and to the point: "Started fishing December 22, 1927 and had hole cleaned January 1st. Finished drilling to 2463 January 10, 1928." The well went into salt water.

F. L. Rye No. 1 (NW. Cor. NE. 1/4, NW. 1/4, Sec. 22, T. 15 S., R. 17 W.), on the Frank L. Rye farm about a mile north of the Monroe County-Lowndes County line, was one of the most interesting and controversial wells drilled in the county or the state. It was financed by Natural Gas and Fuel Corporation of the Brummitt-Demonstrand interests during the first phase of the work, and by Arkansas Natural Gas Corporation for the second phase. The first period of drilling began March 30, 1927, and ended November 13, or a little later. On November 13, at 2691 to 2693 feet, the well blew in, making around 3,180,000 cubic feet of gas and some water. Initial rock pressure was said to be 980 pounds. Although the drilling was continued to a total depth of 2715 feet, the gas flow was from 2691 to 2705, or from 2693 to 2701. Production appears to have increased and declined, but in January, 1928, a decision to shoot the well had been made, in the hope that by shooting the flow of gas would be materially increased. The effect of the shot was to run the flow of gas upwards—some reports said to 5,000,000 to 8,000,000 cubic feet—but it quickly dropped again, and gradually died out. In November?, 1928, Mr. P. J. MacAlpine was engaged to deepen the hole, which he did, to a total depth of 3710 feet. During this second period of drilling numerous gas shows were reported, including 82,000 cubic feet at 3536 to 3539, increasing to 102,000 from 3539 to 3540, and to 150,000 from 3543 to 3546, and 82,000 at 3710 feet. The well was finally abandoned September 9, 1929.

The record of an analysis of gas, beginning at 2693 feet, from the F. L. Rye No. 1, by The Detroit Testing Laboratory (R. Spokes),[131] is given below:

Analysis

	Sample 1	Sample 2
Carbon dioxide	0.9	0.6
Illuminants (unsaturated hydrocarbons)	1.2	1.0
Oxygen	0.5	0.2
Carbon monoxide	0.5	0.7
Methane	90.2	83.9
Hydrogen	None	None
Nitrogen (inert gas)	6.7	15.6

Sample 2 had considerable moisture.

During the spring of 1927 several wells were started in the area by various promoters, but none went to any considerable depth. It was rumored that they were located more with reference to the territory where the greatest number of leases could be blocked than on the basis of geology. Three of these wells may be referred to briefly.

L. B. Mawk and Company Seavey No. 1 (Sec. 22, T. 13 S., R. 7 E., SW. 1/4 SW. 1/4, about 250 feet north of the SE. corner), about 5 miles west of Amory, began drilling April 1, 1927, and was abandoned in December, 1927. It is said to have reached a depth of 536.5 feet.

Acker No. 1, A. M. Sutton et al (SW. 1/4, SW. 1/4, Sec. 25, T. 13 S., R. 19 W.), on the Acker farm some 6 miles north of Aberdeen, was begun April 24, 1927, and abandoned a few months later. It was reported to have encountered a heavy flow of water at approximately 673 feet.

J. H. Taylor No. 1, R. E. Zundt et al (NE. 1/4, SW. 1/4, Sec. 30, T. 14 S., R. 17 W.), 15 miles southeast of Amory, was begun May 1, 1927. No additional information is available.

The Day No. 1 well, on the C. C. Day land (NW. 1/4, NW. 1/4, Sec. 18, T. 16 S., R. 18 W.), near the junction of the Tombigbee and Buttahatchie Rivers, was begun August 11 or 12, 1927, and completed May 14, 1928, to a depth of 4093 feet, the greatest depth reached by any well in the county except the Carter Oil Company well. The enterprise was backed by the Texas Company, the Arkansas Fuel Oil Corporation (Benedum-Trees), and the Transcontinental. A very heavy water flow was struck about 800 feet, according to reports; several salt water horizons were reported also, and a gas pocket of 10,000 cubic feet at 3992 feet, in 2 feet of sand.

The Bourland No. 1 (Sec. 2, T. 13 S., R. 19 W., 300 feet south and 500 to 600 feet west of the northeast corner of the section), about 1.1 miles southwest of Amory, was begun September 24, 1927, by the Charles L. Tubb Company (local), who took it to 354 feet with a rotary outfit. From this depth it was taken over by the Amory Development Company (P. J. MacAlpine, drilling contractor), who completed it to 3015 feet with cable tools, beginning August 24, 1928. Unusual interest was aroused by this well, not only because of some reported shows of oil and gas, but because of the geological features. A good oil showing was claimed to have been encountered at 745 feet, and another at 1085; gas was noticed at 2300, and at 2860 to 2977 enough gas was obtained to burn in the boiler each morning, according to the driller's log. Much water was encountered, also, and was never successfully shut off.* It may be pertinent to note here that Fletcher[13c] determined by the ether test that a sample marked 1095 to 1100 feet, which was supposed to have shown live oil, did not show any, and that none of the samples for 50 feet above the 1095-foot depth showed any evidence of oil.

*In some quarters cessation of flow of several wells in Amory and vicinity was attributed in large part to lowering of the head by the heavy flow from the Bourland well.

The Amory Natural Gas Company Carter No. 2 (Sec. 7, T. 13 S., R. 17 W., 135 feet north and 50 feet east of SW. Cor. NW. 1/4 SE. 1/4, some 600 feet north of Carter No. 1), was begun January 28, 1929, as an offset to Carter No. 1, and completed September 4, 1929, at a depth of 2582 feet, as a small gasser. The initial production was only 149,000 cubic feet, and the rock pressure 600 pounds. When tested in May, 1930, under open flow conditions, the production was 230,000 cubic feet a day of gas having a rich gasoline odor and no water. The flow increased to 360,000 two days later, and the pressure ran about 500 pounds. The maximum production was said to have been 500,000 cubic feet open hole flow. An analysis of gas from this well, by the U. S. Department of Commerce Bureau of Mines Cryogenic Laboratory of the Amarillo, Texas, Helium Plant (C. C. Anderson, Associate Chemist of Field Survey Section),[13f] found the composition of the gas to be: Carbon dioxide, 0.78; Oxygen, 0.47; Methane, 96.14; Ethane, 1.10; Nitrogen, 1.35; Helium, 0.16.

Carter No. 2 was abandoned by the gas company September 29, 1932.[13j]

Cowart No. 1 (NE. 1/4, NE. 1/4, SW. 1/4, Sec. 2, T. 12 S., R. 9 E.), known also as the Smithville well, the Bowser well, and the Cowart-Bowser well, was begun February 12, 1929, and finally abandoned February 8, 1932. P. J. MacAlpine contracted to drill the well for a Mr. Park Bowser, but as the deal worked out he was obliged to take up all the leases and do the drilling almost entirely at his own expense. The chief feature of the well was that the drill was reported to have reached the upper Trenton; but the log appears to indicate that the Knox was penetrated to a considerable depth. The total depth was 3795 feet, and but for a disastrous fire which destroyed the drilling rig, the hole might have been carried even deeper. An excellent showing of oil was obtained from the bottom of the hole, and all arrangements had been made to make a test, when the fire occurred, November 9 or 10, 1931.

Carter No. 3 (Sec. 7, T. 13 S., R. 17 W., center SE. 1/4, SE. 1/4, about 1270 feet east by 195 feet south of Carter No. 1), of the Amory Petroleum Corporation, was begun October 16, 1930, and completed January 6, 1931, at a depth of 2400 feet. It was brought in as a small gasser, the gas being struck at 2396 feet; the initial production was 321,500 cubic feet, and the rock pressure 380 pounds, according to the gas company's records, but other figures on the initial production are 100,000, 201,800, and 484,000 cubic feet a day. The flow is said to have increased to 500,000 cubic feet after shooting.

The Amory Petroleum Corporation Harris No. 1 (Sec. 18, T. 13 S., R. 17 W., center of NW. 1/4, NE. 1/4, about 0.5 mile SSE. of Carter No. 1), was begun January 28, 1931, and completed April 5, 1931, at 2399 feet, where a strong flow of gas and a rock pressure of 512 pounds were encountered. According to reports, on April 5 the well gauged 4,068,000 cubic feet, and on April 6 it gauged 5,598,000 cubic feet. Later, if certain other reports are true, it rose to 7,000,000.

The Charles Rye No. 1 (Sec. 22, T. 15 S., R. 17 W., center of NE. 1/4, NW. 1/4, about 0.3 mile south of F. L. Rye No. 1), referred to also as "Rye No. 2" and "MacAlpine's Rye well," was drilled between June 8, 1932 and May 13, 1933, by P. J. MacAlpine at his own expense. No gas was found, but at 2868 feet an oil-saturated sand was struck, which, however, proved to be only 0.5 foot thick. Its total thickness was included in a 6-inch core. In standing over night in a can, this core exuded 1.5 inches of oil in the can. An attempt to shoot the well resulted in the shot being exploded prematurely, in the shale above the sand, and the hole was abandoned. Its total depth was 2917 feet.

F. L. Rye No. 2 (Sec. 15, T. 15 S., R. 17 W., NE. 1/4, SW. 1/4, 184 feet north of the south line and 469 feet west of the east line), called also "Rye No. 3", was begun August 13, 1934, and completed December 20, 1934. The well was drilled by P. J. MacAlpine at his own expense, and a rotary rig was used all the way. The total depth was 2931 feet, and the hole was dry.

The Roberts No. 1 (NW. 1/4, Sec. 18, T. 13 S., R. 17 W.) was begun towards the end of 1939 or in January, 1940, by the Wilmot Oil and Gas Company, specifically F. M. Tatum. The well reached a depth of 2879 feet, but got no production.

Willard Rye No. 1 (Sec. 22, T. 15 S., R. 17 W., about 0.5 mile east of F. L. Rye No. 1) was drilled in 1940 by the Tatum interests on the Willard Rye land. It reached a depth of 2745 feet, but found no oil or gas.

During the fall of 1941 and the early part of 1942 the Carter Oil Company drilled a very deep test well in the southwestern part of the county (SW. 1/4, Sec. 22. T. 15 S., R. 6 E.), near Prairie. Every effort was made by the company to keep their progress and results secret. Later the total depth was given as 6059 feet (Plate 3).[43]

Mr. H. G. D'Spain,[13j] General Manager of the Mississippi Public Service Company, Amory, stated that the total production of the Amory Gas Field was probably not more than 1,500,000,000 cubic feet, including the 500,000,000 to 540,000,000 cubic feet estimated to have been wasted during the three months when the discovery well was allowed to run wild.

From the foregoing review of the story of oil and gas prospecting in Monroe County, some facts as to general results may be gleaned. If the records are to be believed, almost every well got some showings of oil or gas, or both; five of the wells produced sufficient gas to be ranked as commercial producers, at least for a short time; one or two wells yielded small quantities of oil; all production of consequence was from depths not greater than 2700 feet; all production was from Pennsylvanian or Mississippian strata, or perhaps from the Mississippian alone.

Reasons given for the failure of most of the wells to produce oil or gas in commercial quantities, and the short life of the wells which did produce, are various. Perhaps not more than two or three of the wells were located on definite structures; it may be that in some if not most cases considerations other than geology determined locations. Also, that the management was such as to hinder rather than help the drilling; that in some cases the drillers were so incompetent that they lost the wells concerned; that unsuitable and inferior equipment was used; that deliberate dishonesty was practiced in some cases—all these charges and others were made and accepted as truth by people who were disappointed in one way or another and were trying hard to make themselves believe that the human element rather than the cosmic had failed them. Possibly all these factors contributed to the inescapable fact that the Monroe County oil and gas development program, which started so auspiciously, "flared and funked," but a little further analysis of the geological conditions of the region, in the light of geological conditions and the results of test wells in nearby territory, may suggest additional causes for the disappointing showing of the Amory field to date. Possibly the geologist[13h] who said, "The limits of production in the Carter gas sand appear to be very small in the Amory Gas Field" stated one reason for the lack of appreciable success of the drilling campaign; but the answer to this may be found in deeper drilling, less dependence on the Carter sand. That *some* oil and gas are in the rocks has been proved both directly and indirectly; the one fact that they have been encountered in wells is sufficient proof that at least small quantities are there. But the questions to be answered are: Whether or not the strata are sufficiently petroliferous to provide the material for large accumulations, and whether or not suitable structures or traps of sufficient size to accommodate large deposits exist in the region. By "large" accumulations is meant concentrations large enough to be of commercial importance.

SUMMARY OF CLASSIFICATION AND DESCRIPTION OF THE PALEOZOIC ROCKS OF MISSISSIPPI AND ALABAMA, ESPECIALLY OF NORTHEASTERN MISSISSIPPI AND NORTHWESTERN ALABAMA. [9 11 17]

Pennsylvanian system

Pottsville series, Lower Pennsylvanian

Pottsville formation (Butts)

The Pottsville formation is composed of shale and sandstone and coal beds. The lower part, which underlies part of northeastern Mississippi, is almost all shale and sandstone, only a few thin coal beds being included. The thickness of the entire Pottsville of Alabama is said to be 9000 feet, but in northwestern Alabama the formation probably does not exceed 2500 feet, and under the surface of Monroe County, Mississippi, its maximum thickness may be about the same (Rye and Day wells) but it is less farther north (1550 feet in Roberts No. 1).

Great unconformity

Mississippian system

Chester series

Pennington formation

The Pennington formation of northwestern Alabama is red and gray shale and a few thin argillaceous limestones on the outcrop. Its maximum thickness in Alabama is given as around 200 feet, and the average about 50 feet, but greater thicknesses have been recorded by well logs. The Pennington has been reached in several Monroe County wells, where its red or pink shale is a good horizon marker.

Bangor formation

The Bangor formation outcrops of northwestern Alabama show limestone chiefly: thick-bedded, blue, largely coarsely crystalline or oolitic; but the lower part of the formation in Colbert and Franklin Counties is shaly and marly, and the beds are in general very fossiliferous. The Bangor becomes more shaly southwards. Its thickness ranges from 100 to 700 feet; in Franklin and Colbert Counties it may be 500 feet at least, but it is less southwards. Various thicknesses were penetrated by the Monroe County wells, but Roberts No. 1 passed through only 190 feet of Bangor and Pennington combined.

Forest Grove formation (Hartselle of Alabama)

The Forest Grove formation of Tishomingo County, Mississippi, includes a lower member composed of clay shales and sandy shales and shaly sandstone, and an upper thick, massive, cliff-forming member, the Highland Church sandstone. The formation is 115 feet thick, at its outcrops, but is assigned a thickness of 190 feet by the log of Roberts No. 1, eastern Monroe County. In northwestern Alabama the same formation, known as the Hartselle, is a thick-bedded to thin-bedded sandstone, 200 feet thick in Colbert County.

Southward Bridge formation (Golconda of Alabama)

The Southward Bridge formation consists of a lower and an upper limestone, each underlain by thick shale, the total thickness of the formation being 80 feet. It has not been differentiated in Monroe County wells. The Golconda, the equivalent formation in Alabama, is described as a green marl, with an oolitic limestone at the base in Colbert County.

Southward Spring formation (Cypress formation of Alabama)

The Southward Spring formation is an impure shaly somewhat calcareous sandstone 30 feet thick. The correlative Cypress formation of Colbert County, Alabama, is a thick-bedded sandstone 40 feet in thickness. In Monroe County wells the Southward Spring has not been separated from other units.

Southward Pond formation (Gasper formation of Alabama)

The Southward Pond formation consists of three beds of limestone, each underlain and overlain by shale; the basal limestone is oolitic and asphaltic. The formation has a thickness of 80 to 100 feet. It has been recognized in Monroe County wells, but not delimited. The Gasper, the equivalent formation in Alabama, is composed of an asphaltic oolitic limestone at the base, overlain by marl and limestone; the total thickness ranges from 100 to 150 feet.

Allsboro formation (Bethel of Alabama)

The Allsboro formation is a coarse contorted slightly asphaltic sandstone 8 feet thick. It was recognized in the study of cuttings from the Roberts No. 1 well, where a thickness of 32 feet was suggested. The correlative Bethel formation of Alabama consists of 12 feet of sandstone, thick-bedded to shaly, and locally asphaltic.

Alsobrook formation (Ste. Genevieve formation of Alabama, according to Butts)

The Alsobrook formation consists of a basal very fossiliferous (*Productus inflatus*) limestone overlain by thick clay shales or shaly or thin sandstones through a thickness of 80 to 90 feet. No doubt the formation was penetrated by the deeper wells in Monroe County, but is not named in any of the logs or reports. In Alabama the equivalent of the Alsobrook formation is said by Butts to be the Ste. Genevieve formation, but the Alsobrook is considered basal Chester series by Morse, whereas the Ste. Genevieve is the uppermost member of the Meramec series: the true Ste. Genevieve formation underlies the equivalent of the Alsobrook in the standard Mississippian section of the middle part of the Mississippi River valley. Butts's Ste. Genevieve of Alabama is composed of 75 to 100 feet of marl and thick-bedded, light-gray oolite.

Floyd formation

The Floyd formation is the shale phase of the formations named above, from the base of the Gasper, and probably from the base of the Ste. Genevieve, to the top of the Bangor. That is, south and southeast of the northwestern Alabama outcrop areas of the Chester formations, a lateral gradation to a shale facies has been developed, and the whole body of rock between the vertical limits indicated above has been named Floyd shale, although it includes lenses and layers of sandstone and a few thin limestones. Chester fossils have been found here and there, but in general the formation is non-fossiliferous. The Floyd may be represented in some Monroe County wells, occupying the interval which belongs to the Chester formations farther north and east. Possibly the substitution of the dominantly shale facies of the Upper Mississippian formations for the shale-sandstone-limestone facies of the outcrop areas is one reason for the tangled web woven by the would-be correlators: where lithology is so much changed and fossils are all but absent, few bases for accurate correlation remain.

Meramec series of standard section (middle Mississippi Valley). Lower (Iowa) series of Tishomingo County, Mississippi. The Lower (Iowa) series represents the entire Kinderhook, Osage, and Meramec series of the standard section and of Alabama.

Iuka formation of Mississippi

The Iuka formation, as represented in Tishomingo County, Mississippi, includes the Mississippi equivalents of the Fern Glen formation of the standard section (possibly); the Burlington and Keokuk formations of the standard section, and the Warsaw, Salem, St. Louis, and possibly the Ste. Genevieve formations of the standard section. The Fern Glen, Burlington, and Keokuk are included in the

Fort Payne formation of Alabama. The Iuka is composed of chert, pulverulent silica, and a very little limestone, and has a thickness of about 170 feet.

The Ste. Genevieve formation part of the Iuka (if any) has not been differentiated from the remainder of the terrane, but in Alabama, as stated, consists, according to Butts, of 75 to 100 feet of marl and thick-bedded, light-gray oolite.

St. Louis formation is in Mississippi sparingly represented by chert and possibly a little limestone in the Iuka terrane. Identification was based largely on the type fossils, *Lithostrotion canadense* and *L. proliferum*. In northwestern Alabama, where it constitutes the upper part of the old Tuscumbia formation, the St. Louis is a thick-bedded dark fine-grained or light-gray coarsely crystalline limestone containing the fossil coral Lithostrotion. Its thickness in Alabama has not been definitely stated, but can not be very considerable.

Salem or Spergen formation is represented in Mississippi by chert in the Iuka formation, and in Alabama by at least 6 feet of crystalline light-gray to white limestone, and possibly much more.

Warsaw formation is in Mississippi undifferentiated Iuka, but in Alabama is a coarsely crystalline gray fossiliferous limestone containing much chert. Butts assigned it a thickness of 200 feet near Sheffield, but probably this includes Salem and St. Louis as well as Warsaw rock. It makes up the greater part of the old Tuscumbia formation, which included the Salem (Spergen) and St. Louis also.

Osage series of standard section

Lower (Iowa) series of Tishomingo County, Mississippi

Iuka formation of Mississippi, Fern Glen, Burlington, and Keokuk formations of standard sections, all of Fort Payne formation of Alabama except the lower part.

The Osage series of the standard section is represented in the Iuka formation of Tishomingo County, Mississippi, by chert containing characteristic fossils. In Alabama all rock of this age is included in the Fort Payne formation, of which it includes all except the lower part. The Fort Payne is composed of coarsely crystalline thick-bedded crinoidal and thin-bedded argillaceous limestones; much black flint and chert in the limestones and weathered from them; and dark siliceous shale which is 60 feet thick in places. The formation has a total thickness of 200 feet in Alabama. It is the equivalent, in part at least, of the old Lauderdale Chert of Alabama.

Kinderhook series

Lower (Iowa) series of Mississippi

Carmack formation of Tishomingo County, Mississippi; lower part of Fort Payne formation of Alabama and of old Lauderdale Chert

The Carmack formation consists of some 100 feet of limestone, thin-bedded, brownish-gray or bluish-gray, whick breaks into thin shaly layers on exposure. The Fort Payne has been described above. In places at the base of the Fort Payne a thin greenish shale crops out, a little phosphatic in places; this may be the equivalent of the Maury phosphatic green shale of Tennessee. The entire Fort Payne is equivalent to the older Kinderhook series, the older Fern Glen formation, the oldest Burlington, and the Keokuk formation of the standard section.

Great unconformity

Devonian system

Upper series of Tishomingo County, Mississippi; Chautauquan of standard New York section, at least in part; Whetstone Branch formation (Mississippi); Chattanooga formation of Alabama.

The Whetstone Branch formation consists of some 30 feet of black shale, sandy shales, and thin sandstone. The Chattanooga formation of northern Alabama is a black, fissile shale and a thin sandstone, the sandstone being either at the base or in the middle of the shale, and the entire formation being only 2 to 10 feet thick. In Tennessee the sandstone is known as the Hardin. Butts considers the Chattanooga basal Mississippian in age, but Morse maintains that it is uppermost Devonian (Upper Series) in Mississippi.

Unconformity

Oriskanian series and some younger rocks

Island Hill formation of Tishomingo County, Mississippi;
Frog Mountain formation (in part) of Alabama

The Island Hill formation is only 3 feet of a thin basal limestone conglomerate and cherty and siliceous limestone. The Frog Mountain is of Oriskany age, but includes younger strata also; it is a coarse-grained to fine-grained hard chalky sandstone of varying thickness.

Unconformity

Helderbergian series (Lower Devonian)

New Scotland formation

The New Scotland of Alabama and of Mississippi is a massive bluish-gray siliceous fossiliferous limestone, so far as outcrops show. It is 40 feet thick in Tishomingo County, Mississippi, and 50 feet in Lauderdale County, Alabama.

Silurian system

Oswegan, Niagaran, possibly Cayugan series (Lower, Middle, and Upper Silurian)

Red Mountain formation

The Red Mountain formation of Alabama includes the Brassfield (Medinan age, Lower Silurian or Oswegan) as a lower member, and the Clinton (Niagaran, Middle Silurian) as an upper member. It is sandstone, shale, limestone, conglomerate, and iron ore in the Birmingham region, and chiefly limestone in northwestern Alabama. The formation thickens westwards, but thins northwestwards, and is represented in the northwestern corner of Alabama by the Brassfield limestone, 15 to 25 feet thick. In Tishomingo County, Mississippi, the Mellen and Gear Wood No. 1 well found 100 feet of Silurian strata, including 5 to 10 feet of glauconitic coarsely crystalline pinkish Brassfield limestone at the base, and around 90 feet of reddish, greenish, and cream-colored limestones and shales of the Wayne formation above. Some beds in the extreme northwestern corner of Alabama may belong to the Salina (Cayugan, Upper Silurian). The total thickness of the Alabama Sulurian ranges from 15 or 20 feet up to as much as 700. It seems to thicken southwards from the northwestern corner of the state.

Ordovician system

Mohawkian and Cincinnatian series (Middle and Upper Ordovician) Chickamauga formation

The Chickamauga formation of Alabama includes all the Ordovician units of the state above the Little Oak limestone: more than half of the Middle Ordovician (Mohawkian) and all the Upper (Cincinnatian) that exist in Alabama. It is "an aggregate of limestone deposits;" in general limestone and shale, but contains subordinate conglomerate and bentonite. The limestone is medium thick-bedded blue fine-grained, including one or two 20-foot beds of cobbly limestone in the lower 75 feet, some red limestone or mottled pink and red, and some gray argillaceous nodular limestone; the shale is greenish clay shale; the conglomerate is basal. The bentonite is in strata of Lowville (Black River) and basal Trenton age, in the lower part of the Chickamauga.

The Ordovician units of other parts of the country which are represented in the Chickamauga are classified under a number of names: Richmond, Maysville, Eden, Trenton, Black River, Stones River, and so on. The Trenton in Tennessee is made up of four formations: Hermitage, Bigby, Cannon, and Cathys, of which the first two are absent in Alabama. The Stones River of Tennessee includes four formations: Murfreesboro, Pierce, Ridley, and Lebanon.

All the formations named are limestones. The Trenton proper is about 200 feet thick in Tishomingo County, Mississippi, and Colbert County, Alabama. The Chickamauga formation runs about 500 feet maximum thickness.

Unconformity

Chazyan series

Little Oak formation

The Little Oak limestone of Alabama is thick-bedded, dark, coarsely crystalline, argillaceous at top, in places weathered to brownish fragile mud rock, in other places full of clayey veins; it is very fossiliferous. Locally it contains some nodules of chert, and here and there has some bentonite in the upper part. The maximum thickness is 500 feet.

Athens formation

The Athens is a black, fissile shale and some layers of impure dark to black limestone and a few thin layers of gray compact limestone; locally it is very fossiliferous, graptolites being especially abundant. A highly fossiliferous limestone at the base is an excellent datum. The maximum thickness is around 300 feet.

Unconformity

Lenoir formation

The Lenoir is a limestone, dark finely crystalline medium thick-bedded, non-magnesian or low magnesian, clayey or silty. Locally the basal layers are a conglomerate of chert and limestone pebbles. The formation is fossiliferous: Maclurea is a typical fossil; the Lenoir is correlative with the Ridley of Tennessee. Its thickness is 500 feet.

Mosheim formation

The Mosheim limestone is thick-bedded, compact, brittle, and bluish-gray; a weathering feature is the formation of a thick white or gray chalky crust. The rock is fossiliferous: gastropods, especially Lophospira, are abundant and varied. The age of the formation is post-Beekmantown, and the thickness 50 to 100 feet.

Unconformity

Beekmantown or Canadian series

Odenville formation

The Odenville limestone is dark fine-grained cherty impure, argillaceous and siliceous, and fossiliferous. It is of upper Beekmantown age; the thickness is 50 feet.

Newala formation

The Newala formation consists of much limestone and little dolomite. The limestone is thick-bedded, compact or non-crystalline or textureless, dark-gray, pearly-gray, or bluish-gray, but chiefly pearl-gray. The dolomite is in the form of layers or is interfingered with the limestone, making a mottled rock; it is coarse-grained. The thickness of the Newala is about 1000 feet maximum.

Longview formation

The Longview is a cherty limestone and dolomite of lower Beekmantown age; the limestone is light-gray and thick-bedded; the chert is compact, but brittle and fragile. Fossils are present, including Lecanospira. The thickness is 500 feet.

Great unconformity

Ozarkian system (Cambro-Ordovician)

Knox series

Chepultepec formation

The lower 350 feet of the Chepultepec formation is compact, light-gray thick-bedded limestone, including some inter-bedded dolomite. All above this is dark-bluish coarsely crystalline dolomite, thick-bedded and thin-bedded, containing abundant cavernous and fossiliferous chert, which is soft, mealy, and resembles worm-eaten wood. The total thickness of the Chepultepec is 1100 feet.

Copper Ridge formation

The Copper Ridge is a rather thick-bedded light-gray fine-grained to coarse-grained siliceous dolomite, containing much secondary chert, dense, tough, hard, and jagged. Fossils are few; Cryptozoa have been found. The Copper Ridge formation is about 2000 feet thick.

Bibb formation

The Bibb formation is a thick-bedded dark coarsely crystalline highly siliceous dolomite, containing bowlders incrusted with cavernous drusy silica; it is non-fossiliferous. The weathered layers may be deeply pitted. The maximum thickness of the Bibb is 500 feet.

Ketona formation

The Ketona dolomite is coarsely crystalline, light-gray, and thick-bedded; it is very pure carbonate of magnesium and calcium, and contains no chert. No fossils have been found in the Ketona. The thickness is 600 feet maximum.

Brierfield formation

The Brierfield is chiefly thick-bedded coarse-grained highly siliceous steely blue dolomite. Residual bowlders have a fretwork of silica or relatively deep cavernous incrustation on weathered surfaces.

In the lower part of the formation are bowlders of dense, smooth, rounded chert, and pitted cavernous weathered layers. *Cryptozoon proliferum* is the only fossil. The thickness of the Brierfield is 1500 feet.

Great unconformity

Cambrian system

Middle and Upper Cambrian (Acadian and Croixian series)

Conasauga (old Coosa or Flatwoods) formation

The Conasauga consists of shale, limestone, and dolomite in varying proportions in different areas. The limestone is dark-bluish to dark-gray, fine-grained, thick-bedded to thin-bedded; much of it is argillaceous, weathering to clay which preserves original bedding and thickness; it may be banded. The dolomite is dark and thick-bedded. The shale is dark green to yellowish green. Much chert and flint are present. The formation is locally highly fossiliferous. Its maximum thickness is 1900 feet.

Middle Cambrian (Acadian) series

Rome (Montevallo or Choccolocco) formation

The Rome formation is composed of red shale, green shale, reddish or chocolate sandstone, light-gray rusty weathering calcareous sandstone and local beds of fairly pure limestone and dolomite. The shale is locally fossiliferous. The dolomite is bluish-gray, and contains some chert bowlders. The limestone is coarsely crystalline, dark bluish, fossiliferous, and some of it is thick-bedded. The Rome formation is 1000 to 2250 feet thick.

Lower Cambrian (Waucobian) series

Shady formation (Aldrich or Beaver)

The Shady limestone is thick-bedded, fine-grained, and bluish-gray or pale yellowish-gray, and very sparingly fossiliferous. Contains some limonite, which is worked in the residue along the outcrops. The thickness of the formation is 500 to 1200 feet.

Weisner formation

The Weisner is composed of shale or slate and relatively thin (5 to 100 feet) beds of quartzite and conglomerate. The shale is dark blue and weathers to yellowish-gray; it contains lenses or layers of sandy hematite. The thickness of the Weisner exceeds 1700 feet.

Undifferentiated Proterozoic and Paleozoic rocks

Talladega formation or series

The Talladega is slate or sericitic phyllite, and interbedded conglomerate, sandstone, limestone, marble, dolomite, chert, graphitic phyllite, and quartz schist. Several minor units or members are included in the Talladega. The phyllite is commonly dark slate-colored or slightly greenish fine-grained, very smooth and silky looking on cleavage surfaces.

This mass of metamorphosed rock is said to range in age from pre-Cambrian to post-Devonian. Its total thickness is around 30,000 feet.

The question of oil and gas reservoirs is logically the first to consider. Several very competent geologists have agreed that in this area commercial production, if obtained at all, must come from the Paleozoic beds, because the Cretaceous formations, if their true character and condition can be judged from outcrops and well findings, are too heterogeneous of structure or lithology, or contain too much fresh water, or lack impervious cover except in the Selma chalk part of the county.[11] Nevertheless great expectations have been raised at times in the past by certain promoters who have all but promised oil or gas production from the Cretaceous beds simply because these beds happen to be equivalents of well-known producing horizons of Louisiana—the Tuscaloosa of the Woodbine, and the Eutaw of the Blossom. The Paleozoic section of Monroe County must of course be inferred from the nearest outcrops or built up scrap by scrap from well logs most of which are masterpieces of concealment where real reliable information is concerned. There are too few scraps, and those which exist are not such good building material. Inferences drawn from the western Alabama and northeastern Mississippi outcrop sections may not be entirely correct, or may even be far wide of the mark, because of lateral changes of beds in lithology and thickness and because of structural factors; nevertheless they should be of some value considered in connection with Mississippi well records, toward getting a fairly accurate general picture.

All available geological information supports the concept of a peneplaned but more or less irregular Paleozoic floor overlain by generally unconsolidated sediments of Cretaceous age. Paleozoic rocks crop out in western Alabama a few miles east of Monroe County, and in Tishomingo County, Mississippi, a relatively few miles north of Monroe County. The Paleozoic surface in western Alabama east of Monroe County slopes southwards and westwards in general, and the dip of the strata is southwards at a low angle—conditions which can be observed readily from the highway leading south from the Tennessee River at Florence, Alabama, through Sheffield, Tuscumbia, Russellville, Phil Campbell, Hackleburg, and Hamilton, to Guin, thence westwards through Sulligent and Gattman. The divisions of the Mississippian system are exposed in numerous places from the Tennessee River south along this route to a level well up on the plateau edge some 6 miles south of Russellville; the uppermost Mississippian formation, the Pennington, of which only 33.5 feet are exposed here, and 12.0 feet of the Bangor limestone underlying it, show in the plateau escarpment beneath some 175 feet of Pennsylvanian (Lower Pottsville) shales and sandstones, and 50 feet of Tuscaloosa.[16] In Tishomingo County, Mississippi, three Devonian formations crop out beneath the Mississippian, or rather did crop out before the creation of Pickwick Lake.[9] Thus, many of the Paleozoic beds which are present in the northeastern Mississippi and northwestern Alabama region can be observed along the public roads between the Mississippi-Tennessee line and the latitude of Monroe County. Of these formations, all below the Pottsville are marine, and for this reason could be expected to maintain their stratigraphic relationships and a fairly uniform thickness over considerable distances. The Pottsville, although of fresh water origin in its upper part except for a few thin marine strata, is said to contain a considerable proportion of marine strata in its lower part, especially below the Black Creek coal seam, which is mined in southern Marion County.[10] In western Alabama it is a monotonous succession of sandstones and shales, including a few coal beds,[17] and could be expected to be made up of much the same kind of materials under eastern Mississippi.

As indicated in the summary, the Paleozoic section of western Alabama and northeastern Mississippi includes several formations capable of containing oil or gas or both; in fact, every system, from the Cambrian to the top of the Pennsylvanian, includes potential oil and gas reservoirs. Semmes names seven distinct oil and gas horizons in this area: some of the Pottsville sandstones of the Pennsylvanian; the Bangor limestone, Hartselle sandstone, Gasper limestones and shales, and Tuscumbia limestone of the Mississippian; the Trenton limestone of the Ordovician, and the Cambro-Ordovician Knox dolomite.[10] The summary which follows was drawn chiefly from Semmes and Mellen.[10 11]

The best shows of oil and gas in the Pottsville have come from the strata near the base of the series, especially below the Black Creek coal. However, the Pottsville sands seem to be better gas than oil containers, as shown by the Fayette wells, but are likely to vary considerably in degree of cementation and thus in their value as oil and gas reservoirs. In spite of the Fayette production (from the Pine Mountain sandstone probably) and other small gas shows as well as a little oil from the lower part of the Pottsville, Semmes concludes: "The great thickness, thorough cementation, and massive character of these sandstones on their outcrop would not indicate that they are favorable oil or gas horizons, but as encountered in depth in the western area along the Mississippi line, their lithologic character may be considerably altered."[10] Mellen also noted that the Pottsville sandstones are locally cemented with silica and are almost non-porous. He states, largely on the basis of findings in Mississippi wells, particularly in Lowndes, Lafayette, and Montgomery Counties, "It appears that west of the Warrior Basin in Mississippi the Pottsville is more shaly and more quartzitic, and that the most favorable area for oil or gas production from the Pottsville is in the Warrior Basin proper of west-central Alabama and adjoining parts of eastern Mississippi."[11]

Semmes mentions a few showings of oil and gas in the Pennington formation of the Mississippian system, and numerous showings in the Bangor limestone. He points out that the Bangor becomes much more shaly in west central Alabama [and presumably in western Alabama and northeastern Mississippi also], thus materially bettering the oil and gas prospects. The Hartselle sandstone underlying the Bangor is the source of a number of asphaltic seeps, and in many places shows heavy asphaltic impregnation at the outcrop, especially in Colbert and Franklin Counties, Alabama. In general the Hartselle [Forest Grove formation in Tishomingo County, Mississippi][9] is a medium-grained to coarse-grained sandstone, friable, containing a large amount of pore space, and thus should be a good oil and gas reservoir; but as indicated by wells, it also shows lateral transition towards the south and west into shaly sandstones and shales. This change is marked in Fayette and Marion Counties, Alabama, and the same conditions are probable in Monroe County, Mississippi, a few miles farther west. Semmes[10] states that gas has been found in the Hartselle in almost every well that has reached it in the Warrior Coal Field area. It probably includes the producing "Carter sand" of the Amory field. The Gasper oolitic limestones and the shales [Southward Pond formation of Tishomingo County, Mississippi],[9] the Bethel sandstone of Colbert County, Alabama [Allsboro sandstone of Mississippi[9]] and the Tuscumbia limestone [Iuka chert of Mississippi[9]] are potential oil and gas containers. The Gasper and Bethel are asphaltic in a number of places, and the Tuscumbia not only has afforded shows of oil, especially in Franklin County, but includes sandy horizons very favorable for the accumulation of oil and gas. Mellen considers it a better reservoir rock than the Chester sandstones.[11]

Only unimportant showings of oil and gas have come from the lower Devonian beds, which include the greater part of 20 to 300 or more feet of bluish-gray siliceous limestone, but the upper Devonian strata, including the Chattanooga shale and the Hardin sandstone, are more favorable. Mellen states that the Chattanooga is everywhere petroliferous, but that the associated sandstones are in general too tightly cemented for good reservoir rocks.[11]

Mellen and Gears Wood No. 1 well, Tishomingo County, obtained a strong hydrocarbon odor from the Brassfield formation of the Silurian system. Mellen states that the Silurian of northeastern Mississippi and northwestern Alabama consists chiefly of the Brassfield below and the Wayne above, the Brassfield being a glauconitic coarsely crystalline pinkish limestone and the Wayne (Niagaran series) reddish, greenish, and cream-colored limestones and shales.[11] Some of the overlying bluish-gray siliceous limestone probably is upper Niagaran; the remainder, lower Devonian (New Scotland).

Bramlette[18] states that fossils obtained from 735 to 760 feet in the Southward No. 1 well, Tishomingo County (Sec. 18, T. 5 S., R. 11 E.) indicated the Brownsport formation of Tennessee (Silurian, Niagaran). Beneath the Brownsport were 20 to 30 feet of variegated red and green shale, which he assigns to the Wayne formation (Niagaran). Some 50 feet of pinkish-gray limestone beneath the red shale, showing in Jourdan No. 1 well (Sec. 9, T. 4 S., R. 11 E., 7 miles north by east of Southward No. 1), is also considered part of the Wayne formation, the red shale belonging to its uppermost member, the Dixon. The Brassfield formation is not mentioned, but possibly is the pinkish-gray limestone included in the Wayne by Bramlette.

Semmes[10] states that the Trenton limestone series (in which he includes the Chazy and Black River) is a famous oil and gas reservoir in Kentucky and Tennessee, and is rated the most favorable horizon in northern Alabama, where it has provided good showings of oil as near the Mississippi line as Atwood in Franklin County. Presumably it underlies all Monroe County, Mississippi, but has been encountered in only the Cowart well there. The Trenton series is composed of thin-bedded bluish and shaly limestones and coarse-grained sandy limestones which are good oil sands. Geologists are agreed that no oil and gas test in Monroe County is adequate unless it reaches the Trenton at least. Mellen[11] is careful to point out that the "'Trenton series" proper does not include the Stones River and Black River series, which are older, and considers unfortunate Semmes' lumping of the Chazy (Stones River) and Black River beds together with overlying beds of Trenton age as his Trenton limestone series. Mellen[11] states that this rather loose use of the name "Trenton" has led to much confusion in nomenclature. These lower limestones, 500 to 800 feet, of the Stones River and Black River series, and not the Trenton, have yielded most of the oil of the Upper Cumberland District, Tennessee and Kentucky, "and have given some of the best shows of oil and gas in northeast Mississippi and north Alabama." He describes these rocks as limestones, "almost free of chert, and showing much variation in texture and in color shades of brown and gray." The Trenton series proper of the middle Ordovician, commonly around 200 feet thick in wells in Tishomingo County, Mississippi, consists of slightly phosphatic dark-gray silty limy shales and shaly or crystalline limestones containing a little chert; it is the series of the upper and lower Sunnybrook production of Tennessee and Kentucky, but in Mississippi seems to have very low permeability and to have afforded no important showings.[11]

The Knox dolomite series, although it has yielded a number of scattered showings of gas and oil, is in most places not productive, because of lack of porosity. However, the Knox is known to contain sandy porous zones in its upper part. The possibilities are better in northwestern Alabama, and presumably in northeastern Mississippi, but in these areas the Knox is far below the surface. Good gas showings were obtained from the Knox in the Frankfort and Atwood wells, Franklin County, Alabama, not far from the Mississippi line.

Mellen, noting that the Knox dolomite series of Cambro-Ordovician (Ozarkian) age "has nowhere in north Alabama or northeast Mississippi been drilled through, nor have the underlying Cambrian shales, dolomites, limestones, and sandstones been tested for oil or gas,"[11] concludes that "there is no inherent geologic reason why the Cambrian sandstones and limestones, if permeable, could not yield commercial oil or gas," and he adds that to reach these strata tests would have to be 7,000 to 12,000 feet deep.[11]

In connection with their relation to oil and gas possibilities, a little further attention may be given the Paleozoic outcrops of Mississippi,[9] which, so far as has been discovered, are all in Tishomingo County (See section). The part of the New Scotland limestone exposed in Mississippi is not asphaltic, and is very compact and crystalline in the lower half; the upper half might be capable of holding oil or gas, under suitable cover, or the lower part of the formation not exposed might be a potential reservoir. However, as has been stated, no important showings have come from the lower Devonian beds. The Island Hill formation is too thin to be considered; but the Whetstone Branch sandy carbonaceous shales and thin sandstones, correlative with the Hardin sandstone of Tennessee, the Frog Mountain sandstone of Alabama (in part), and the Chattanooga shale of both states, are lithologically favorable. The Hardin was identified in the Bourland well, Monroe County. The Carmack limestone, which is the Lauderdale or Fort Payne of Alabama, at least in part, is clayey, compact, dense, fine-grained where exposed in Mississippi, but may be more porous under cover at a distance from the outcrop. The Iuka, judged from the outcrops, has plenty of pore space, and in Alabama, where it is called the Tuscumbia limestone, it contains sandy layers which are good oil and gas reservoirs and has produced good showings, especially in Franklin County. The Chester series formations in Mississippi are without exception lithologically favorable for oil and gas reservoirs. The Alsobrook includes the Cripple Deer sandstone and the Hargett sandstone members, which are strongly asphaltic and are quarried for road asphalt at Cherokee, Alabama, or near it; the Allsboro sandstone also is asphaltic, and the Southward Pond limestones and shales carry a large content of bitumen, especially the lowest limestone, known as Pond limestone "A," which is quarried for road asphalt at Margerum and Colrock, Alabama.[9] The Southward Spring sandstone also is asphaltic. Judged from its character at the outcrops, the Southward Bridge formation too could be suitable for the accumulation of oil and gas, and the Forest Grove, which is the Hartselle of Alabama in part, is a well known gas container, as has been stated. As summed up by Morse:[9] "Bitumen-bearing limestone and sandstone, suitable for asphaltic road and street pavement, exists in small areas [of Tishomingo County]; and the presence of such petroleum residue shows rather conclusively that down-dip away from the region of outcrops, these beds will be productive of oil or gas, provided a favorable structure in the form of an anticline or dome existed to entrap the hydrocarbons." However, the few wells which have sought oil or gas in Tishomingo County found only small showings, or "dead" oil. One, drilled on the Southward Pond dome, is reported to have had considerable trouble with crevices or small caves, and to have obtained a few barrels of "dead" oil. It was abandoned at 2472 feet. Two other wells were not on structure, but reported slight showings of oil or gas.[9] The Mellen and Gear Wood No. 1, drilled on structure, reached a depth of 1845 feet, and reported a flow of 40,000 cubic feet of gas.[11]

It would appear, then, that the Paleozoic strata underlying Monroe County include a considerable number of potential oil and gas reservoirs, and that the outcrops of western and northwestern Alabama and northeastern Mississippi not only suggest this, but by asphalt seeps and bitumen showings strongly suggest the presence of oil and gas in the region, or at least its former presence. The records of a considerable number of wells seem to prove the same things. The carbon ratios, also, seem to favor eastern Monroe County as a possible oil producing region. Semmes's carbon ratio map of northern Alabama shows the 55 percent isocarb passing through southeastern Marion County and touching southeastern Lamar, less than 20 miles from Monroe County, Mississippi. Semmes states that most oil fields lie between the 50 and 65 percent isocarbs.[10]

From studies of the regional geology, including some first-hand drilling experience, Mellen[11] reached three general conclusions bearing on the oil and gas situation in northeastern Mississippi and northwestern Alabama: Asphaltic oil residues indicate an escape of the volatile hydrocarbon fractions; accumulation of oil residue is due to up-dip migration of the oil, not to movements vertically upward along faults or other fractures; the more notable concentrations of asphalt indicate structural areas where the prospects for commercial production of oil or gas from the lower strata should be carefully studied. Obviously he believes that prospecting down dip from the chief asphalt accumulations would have a better chance of success than would prospecting in areas not closely related to such deposits.

In summing up the results of his study of the region, the same writer states that of more than 250 Paleozoic test wells, hardly one failed to get showings of oil or gas, and many could have gotten a few gallons or a few barrels of oil a day. He adds: "It is almost impossible to drill a well in the region without evident shows," and expresses his opinion that the explanation of this is to be found in "the structural complications of the region and the general impermeability of the rocks, encompassing thin zones of lenticular, secondary, permeability." He expresses confidence that commercial production of oil and gas will yet be obtained in the region.

The strata briefly described from outcrops and wells in adjacent Alabama and northeastern Mississippi should, theoretically, provide an index to the identity and sequence of strata penetrated by the Monroe County wells. However, this correlation is found to be far from simple. Many of the existing logs are incomplete; in some cases the measurements were obviously inaccurate, in other instances the descriptive terms used differed for the same kind of material in different wells, or the published elevations of the mouths of the wells were inaccurate. In a case or two no log of any kind was kept, and no samples taken. Possibly certain conceptions of the structure are based on imperfect and carelessly kept well records, and for this reason can not be sound. But aside from the imperfections of the records, the geologic difficulties are formidable: the variability of the beds themselves in lithology and thickness complicates the problem, and the changes in level or even in stratigraphic relations due to structural irregularities add to the difficulties. The wide difference in interpretation by recognized authorities, as brought out in the discussion, attests the uncertainties involved. For example, the depth to the Paleozoic was placed at three different figures in one well by geologists who had the well log and samples before them. If this trouble is experienced in fixing the Paleozoic-Mesozoic contact, certainly correlation attempts of very doubtful accuracy can be anticipated where the Paleozoic strata are concerned. In spite of the advance alibis, however, an effort is made herein to piece together and summarize the well data and such attempts as have been made at correlation, and relate them to information obtained from wells and outcrops outside the county, in such a way as to obtain a picture of the Paleozoic stratigraphy and structure of Monroe County which in its essential features will have at least a fair probability of correctly reflecting the actual conditions. Possibly the chief "tops" can be placed, within reasonable limits, and an outline of the stratigraphy and structure obtained thus (Plate 4).

Cowart No. 1 is the farthest north well of the county. According to its log, the contacts were determined as follows: Base of Cretaceous, 193 feet; Pennington formation, 193 to 850 feet; Bangor, 850 to 1175 feet; Hartselle, 1175 to 1282 feet; Fort Payne, 1282 to 1615 feet; Chattanooga, 1615 to 1720 feet, or 1615 to 1880 feet; Silurian, 1880 to 2718 feet. The basis for these determinations is not stated, but presumably it was a study of samples. No contacts are given below the Silurian. It will be noticed that the Pennsylvanian is omitted entirely, although it crops out in Lamar County, Alabama, due east of the well only 16 miles, and was penetrated in the Guin well,[10] between 23 and 24 miles east of the Cowart, to a thickness of 1070 feet, if we can believe the log of the Guin well. Hobson, Mellen, and Vestal[16] measured a section of more than 1000 feet of Pottsville strata from the northern edge of the plateau some 6 miles south of Russellville, Franklin County, Alabama, to about 4 miles south of Haleyville, Winston County. Furthermore, in the Carter No. 1 and all the other wells in the eastern part of Monroe County hundreds of feet of Pottsville strata were penetrated. It is true that Butts[19] expressed the opinion, after a study of cuttings from the Bourland No. 1, near Amory, that the entire section of that well is Mississippian; and of course it is possible that no Pottsville is present in Cowart No. 1; but in view of the sections shown in nearby wells, and the proximity of Pottsville outcrops, the presumption is strong that most of the strata included in the Pennington formation in the determinations listed above, are Pennsylvanian. This presumption is strengthened by the 657 feet assigned to the Pennington, whereas that formation shows a thickness of only 60 to 70 feet on the outcrop in the plateau escarpment in Franklin County, Alabama,[16] and only 280 feet in the Guin well.[10] The Roberts No. 1, only 9 miles south of the Cowart, penetrated only 190 feet of Pennington and Bangor combined.[13k] Possibly the fault near the Cowart well has dropped the thousand or more feet of the Pottsville entirely out of the picture, but this seems hardly likely.

S. H. Rook,[131] after a study of samples from 825 to 1120 feet, stated: "All is Upper Mississippian except lower three samples, which are Lower Mississippian." This could allow more than 600 feet for Pennsylvanian strata, but does not necessarily allow anything.

It will be noted, too, that the entire thickness of strata between the Bangor and the Fort Payne is only 107 feet, and is all assigned to the Hartselle. This means that the entire Chester series, except the Hartselle, below the Bangor, is missing, and in addition a large part of the middle Mississippian. Such a concept does not accord with the records of wells to the northeast, nor with the presumption based on outcrops. The Chattanooga, also, is assigned a thickness far greater than is known in outcrops or recorded in other wells of this region. B. W. Blanpied,[13m] of the Gulf Refining Company, held that the white chalky material from around 1900 to 2100 feet is Fort Payne chert, and expressed the opinion that the Silurian beds would be reached at approximately 2700 feet. Cuttings from 2000 feet to 3781 feet were studied by E. B. Hutson,[13n] of the Humble Oil Company, who found no fossil evidence below 2115 feet, but provisionally identified certain groups of strata as listed below:

2115 to around 2422 feet, white chert and limestone, may be Fort Payne, except that

2409 to 2417 possibly are Chattanooga.

2422 to undetermined depth, dark-brown chert and limestone, may be Devonian.

2685 to 2697 probably are Silurian.

2756 to 2761 probably are Ordovician, but Easton thinks

2912 to 2926 are Silurian.

3085 to 3376 probably are Ordovician.

3376 to bottom of well, given simply as "Paleozoic lithology."

All in all, a suggestion seems to be in order that, before such radical structural conditions as must be assumed to be present if the "tops" have the positions assigned on the log of Cowart No. 1, are accepted as fact, a thorough check of all samples be made. It is possible to conceive of the Pottsville having been removed by erosion and faulting here if the site is located above a truncated anticline such as underlies a valley in the Appalachians; but all surface features of the region indicate the normal slope of the flank of a low dome broken by minor irregularities.

The identity and thickness of the beds penetrated by the Bourland No. 1 well, the westernmost of the northern group of wells, have not been agreed on by geologists. The first point of difference was the depth to the Paleozoic. The U. S. Geological Survey favored about 400 feet,[1i] but Fletcher, the Gulf Refining Company geologist, after a study of samples, expressed the opinion that the materials above a depth of 580 feet, and possibly 675 feet, were Cretaceous.[13e] Stephenson thought the top of the Paleozoic was reached at 476 feet.[13c] The present writer ventures to say that the log suggests that the base of the Upper Cretaceous may be around the bottom of the coarse gravel at 380 feet, and the underlying 80 feet of "red gumbo" may be Little Bear, overlying the Paleozoic; that is, the top of the Paleozoic may be at 460 feet.

Charles Butts,[19] of the U. S. Geological Survey, after a study of the cuttings, stated that he was inclined to believe that the entire section below the Cretaceous was of Mississippian age, indicating a change from the calcareous facies farther north to a clastic facies in the latitude of Amory. He stated that three conditions related to the well strata convinced him that the Coal Measures are missing: No coal was encountered in the well, whereas the presence of several seams of coal in the outcropping Pennsylvanian a few miles to the east would warrant the expectation that at least thin seams should extend as far west as Amory; considerable $CaCO_3$ in the rocks penetrated by the well, whereas the Pottsville of Alabama contains little or no lime, being of non-marine origin chiefly; blue clay beds found in the Bourland well are not Pennsylvanian in character, but of a type which could readily be derived from the Mississippian blue calcareous shale or marl. Mr. Butts found few fossils in the cuttings above a depth of 1810 feet, but the limestone implied that the strata belonged to the Mississippian; the interval 1810 to 1815 feet was fossiliferous, the fossils being Mississippian and they as well as the material identical in character with those of the rock found in Carter No. 1 at 2200 feet.[13b] The strata from 1830 to 1915 he identified as Mississippian, [20a] and those from 1975 to 2120 as Fort Payne (Burlington) and Hardin, the dark shale being Fort Payne and the sandstone the Hardin, which, in Tennessee, is immediately under the Chattanooga black shale.[20b] The beds from 2120 to 2400 contained no fossils, and he would not venture an opinion concerning their age, saying that no such sequence of beds was known in outcrops.[20c]

Mr. P. V. Roundy, of the U. S. Geological Survey, examined 27 samples from the Bourland well, representing strata from depths of 2420 to 2580 feet. His report, transmitted by Julian D. Sears,[21a] Administrative Geologist, stated that no fossils were found in the 19 samples covering strata from 2420 to 2531 feet, but that the 8 samples from the beds between 2531 and 2580 contained fossils indicating a probable middle Mississippian age. Butts [22] later assigned a lower Mississippian age to the strata from 2625 to 2860 feet, and Roundy reported that the fossils from the rocks between 2825 and 3015 (the bottom of the well) indicated a probable lower Mississippian age.[21b]

Stephenson[13c] held the view that the sandstone and shale from 476 to 695 feet probably belong to the Pottsville, and later stated: "There is no evidence that the well has penetrated any limestone to a depth of 815 feet, and from this it is surmised that it is still in the Pottsville formation, or at any rate it has not reached the Bangor limestone."

Fletcher could not agree with Butts on the age of the strata. He stated that from the top of the Paleozoic to a depth of 1100 feet, the samples showed the formations to be of Pennsylvanian age.[13c] With reference to Butts's statement concerning the absence of coal in the cuttings, Fletcher averred that "sand with small amounts of lignitic coal was found at 685, 900, 955, and 1025 feet." And he asks, pertinently, "Also will someone kindly tell me what has become of the very fully developed Pennsylvanian conglomerate section which is found on the surface about 15 miles north and east of the Amory wells and which dips underneath the Tuscaloosa to the southwest?"[23] Later, after having examined the cuttings from depths of 1100 feet to 2300 feet, Fletcher[13c] seems to have modified his views somewhat. He agreed with Butts on the approximate depth to the Carter sand in the Bourland well, placing it at 2070 feet, whereas Butts had expressed the opinion that it should be found at 2080 feet. Fletcher, however, held that the lime encountered between the depths 1785 feet and 1915 feet (which depths include the 1810 to 1815 fossiliferous horizon) "bears little lithologic resemblance to that in the Carter well although the fragments of fossils found in both wells are very similar in association," and reached the conclusion that the evidence available suggested that the series of strata are part of the westward marine facies of the Floyd or Pennington shales of the upper Mississippian. Fletcher stated also that he could not concur with Butts on the question of the stratigraphic position of the shale from 1975 to 2090 feet and the sandstone from 2090 to 2120 feet. Butts referred these to the basal Fort Payne and to the Hardin, respectively, the Chattanooga shale being insignificantly represented in the Bourland well. Fletcher, observing that the rock between 1785 and 1915 feet is very similar in some respects to the Gasper lime found in the Guin and Atwood wells, Alabama, and the Evans-Whitesides well in Lee County, Mississippi, maintained that "by no stretch of the imagination could the material below this lime section be referred to the Bethel, Ste. Genevieve, .Tuscumbia-Lauderdale, and Chattanooga formations, if the material in any of the above mentioned wells is representative of these formations," because chert is abundant in the Tuscumbia-Lauderdale section, and has not been found in the Bourland well; besides, the Tuscumbia-Lauderdale section in all the wells of northern Alabama and Mississippi is at least 700 feet thick. He concludes: "This leaves this entire marine section between 1620 and 2470 feet to be placed in the Mississippian system in a formation younger than Bangor, probably Floyd and Pennington. It is entirely possible that this material *is* Bangor, a possibility which necessitates a thickening of the lower Bangor or Hartselle horizons in this area."[13c]

It may be said, with further reference to Butts's statement about the absence of coal seams in the strata penetrated by the Bourland well, that the log of the well at the municipal water plant, Amory, only a little more than a mile from the Bourland well, records 9 inches of hard coal; reported to be of "good quality," under 72 feet of "white marble" (sandstone?), and above 21 1/4 feet of "marble" (sandstone), all of Pennsylvanian age. The top of the Pennsylvanian is logged at 373 feet, and the top of the coal at 445.[4]

So much for an account of the results of scientific study of samples from a single well, which is fairly typical of the story to be told of any one of several wells in this region. Shall we guess, in the case of the Bourland well, that possibly the strata down to 380 feet may properly be assigned to the Upper Cretaceous; the "red gumbo" to the Little Bear (Lower Cretaceous); the beds from 460 say to 1618 feet to the Pottsville, in spite of the presence of lime and the absence of coal; and all rock from a depth of 1618 feet to the bottom of the well to the Upper Mississippian above the cherty beds, the geologic units to be delimited by each geologist as suits his individual predilections? This arrangement might be as useful as any other, until more intensive studies and another crop of guesses are made.

As is obvious from the preceding discussion, authorities do not agree in the correlation of Carter No. 1 and Bourland No. 1. They agree as to the depth of the "Carter sand" in the Bourland well,[13c] but if Fletcher is correct, this producing stratum is not in the Hartselle, as has been announced and generally accepted, but in the lower part of the Pennington, or the upper Bangor, or the Floyd. The thin 1810-15 feet interval in the Bourland well is confidently correlated by Butts with the 2200 feet horizon of the Carter, but Fletcher does not agree except as to the similarity of the fossils. His stratigraphy of Carter No. 1 is simple: 0-720 feet, Cretaceous; 720-1930, Coal Measures; 1930 (or 1925)-2200, Upper Mississippian (presumably Pennington); 2200-2412 (bottom of well), Bangor. Several geologists are said to have made a careful examination of samples from this well, but found no fossils above 2200 feet. Some are inclined to believe that all Paleozoic above this depth is Pottsville.

Carter No. 2, some 600 feet north of Carter No. 1, seems to have reached the Paleozoic at about 529 feet, but apparently no study was made of samples, and the driller's log records a monotonous succession of "black sandstone," "rock," "hard gummy lime," "hard shale," "broken lime," and so on, probably all Pennsylvanian for 1500 feet or more below the Cretaceous, possibly to 2182 feet, where "pink shale" is mentioned which could be Pennington. If so, the well runs somewhat lower than Carter No. 1. Hutson examined a core of shale and sandstone from 2428 feet and thought the rock probably was Pennsylvanian.

Samples below a depth of 565 feet from Carter No. 3, a little east of Carter No. 1, were studied by Brokaw, Dixon, Garner, & McKee,[13h] geologists and petroleum engineers. The samples showed an unbroken succession of sand, shale, and sandstone to a depth of 2170 feet, the colors being gray, yellowish, brown, black, and white; bluish-gray and blue appeared at the deeper levels. Some "limy fragments" are mentioned in the record as having been found in the gray sandstone from 1112 to 1164, but no limestone above 2170. Below this to the bottom of the well (2400 feet) white and gray limestone is interbedded with green, gray, pink, brown, and some black shale. No division into geologic units is attempted, but probably if the top of the Paleozoic were placed at 534 feet, and the top of the Mississippian at 2170, the error would not be great. A "deadly parallel" of the driller's log of this well with the log made from a study of the samples brings out strongly the risk of drawing geological conclusions and making drilling decisions on the basis of correlations from well to well where drillers' logs provide the only data on the wells. The driller's log of Carter No. 3 shows "chalk" and "lime" here and there from near the surface to the bottom of the well. The "chalk" is probably white or gray clay, and the "lime" may be the same or a white sandstone in many cases.

Hall No. 1 well had better oil showings than any other well in the territory, but the driller kept no log; however, samples of cuttings were taken every 5 feet. These samples, from 518 to 2468 feet, were studied by M. M. Kornfield[13p] of the United Gas System; those from 2635 to 2878 by E. B. Hutson.[13n] Butts[13q] stated that fossils in a limestone core from 2200 feet indicated the lower part of the Fort Payne chert (lower Burlington). G. O. Grigsby,[13h] geologist, associated with Brokaw, Dixon, Garner, & McKee, examined the cuttings from 2470 feet to 3045 feet, the bottom of the well. The uppermost sample, from depths 2470-2475 feet, was brown sandstone. The rock from 2475 to 2825 Grigsby designated the "hard shale section," as it consists almost entirely of blue, black, bluish-gray, and dark-gray hard shale. The strata between depths 2825 and 2884 feet are light-gray and brown fine-grained sandstone with some hard dark-gray slaty shale; they are grouped as the "sandstone section." From 2884 to 2985 is another hard shale section, and from 2985 to 3045 is described as a sandstone and hard shale section. Grigsby did not attempt to indicate any formation contacts. The entire section studied is sandstone and shale. A comparison with the section penetrated by the Roberts No. 1 well, only a mile to the southwest, shows similarity between the two. We have an excellent record of the study of cuttings from the Roberts well. In the Roberts well, also, the section is almost entirely shale and sandstone from the top of the Hartselle, at 2310 feet, to the bottom of the well at 2879 feet. It is likely, then, that the Hall well encountered the usual Cretaceous, Pennsylvanian, and Upper Mississippian strata, and that the limestones at higher levels in the Carter wells belong to the Pennington and Bangor formations.

A complete set of samples from the Roberts well below 557 feet was studied by Miss Winnie McGlamery,[13k] paleontologist of the Geological Survey of Alabama. Miss McGlamery expressed the opinion that the contacts between formations penetrated by the well are at the depths stated below:

	Feet
Tuscaloosa-Pottsville (Mesozoic-Paleozoic, Cretaceous-Pennsylvanian)	650
Pottsville-Pennington and Bangor	2120-50
Bangor-Hartselle	2310
Hartselle-Lower Upper Mississippian	2500
Bethel?	2814-2846.

In this connection another example of how different authorities may reach entirely different conclusions through study of the same material comes up: Mr. J. W. Lea of the office of F. H. Lahee identified Roberts well samples from 2416-22 feet and from 2818-22 feet, as Pennsylvanian. Obviously somebody is far afield.

No driller's log of Dill No. 1 above 2154 feet is available, and the rather sketchy record of the strata below that level shows lime and shale for the most part; only a relatively little sand. The deepest gravel found was at a depth of around 390 feet, which may be about the bottom of the Upper Cretaceous; the "very hard red gumbo" from 390 to 440 feet may be Little Bear, and the sandstone from 440 to 458 probably is Pottsville.[13a] Cuttings from every 5 feet of strata were taken, according to reports, but were not studied.

The driller's log of Harris No. 1 is not particularly informative, but a guess as to the positions of the contacts may be allowed. The top of the Paleozoic was reached at 478 feet, according to Grigsby. The log records a long succession of shale, sandstone, slate, and "gumbo" below this depth, with "lime" thrown in here and there, of course, for balance, but the green, black, and pink shale at 2151 feet may indicate the approximate position of the Pottsville-Pennington contact (See Carter No. 1 and Carter No. 3). The remainder of the strata to the bottom of the well (2399 feet) probably is Pennington and Bangor, although the producing sand at bottom, without doubt the Carter sand, may belong to the Hartselle.

Samples from the Harris well were examined by E. B. Hutson,[13a] of the geological department of the Standard Oil Company of Louisiana, who assigned a Mississippian age to a core of brownish sandstone from a depth of 2384 feet.

The log of Durrett Farm No. 1 well is too generalized to be of much use, but at a venture the top of the Paleozoic may be placed at 517 feet, and the top of the Mississippian at around 2294 feet, where "pink slate" was encountered. The remainder of the depth, to 3075 feet, may have reached nearly to the base of the Chester, or Upper Mississippian series.

The stratigraphy of the Rye wells was a subject of some considerable controversy. According to some authorities, the main gas flow from the F. L. Rye No. 1 (2693-2701 feet) came from the Pennington or Bangor—that is, from near the top of the Mississippian; but Fletcher[13c] thought it was from the basal part of the Pennsylvanian. At first, too, the view was taken that the producing horizon was different from that of Carter No. 1, and the gas different in character;[13e] but later, interested parties maintained that the production from both wells came from the same sand, although it is 560 feet lower in the Rye well than in the Carter, if the surface elevations given for the two wells are accurate. If the gas producing sand is the same in the two wells, production from the Rye is from the Hartselle (Forest Grove of Tishomingo County, Mississippi), or from a sand, in the Bangor. It was even contended that a green shale which is superjacent to the producing sand in Carter No. 1 is also present in F. L. Rye No. 1 immediately above the pay sand in that well, but was not mentioned in the log; furthermore, that the same shale was found in De Soto Oil and Gas Corporation's Gardner No. 1, in Lamar County, Alabama, directly east of the Rye well, at 3072 feet and lower.[13r] Such correlation would indicate a south and east dip of the beds of some 40 feet to the mile from the Bourland well to the Gardner. Positions of contacts were given: 0-605 feet, Cretaceous, Tuscaloosa; 605-2409, Pennsylvanian, Pottsville; 2405-2705, Mississippian, Pennington.[10]

The section of the Rye well from 2700 feet to the final depth, 3710 feet, is largely shale and sandstone. The bottom was thought to be in Silurian beds, but probably is not, because if it were, the entire Mississippian and Devonian would be only 1000 feet thick here.

The F. L. Rye No. 2 reached the Paleozoic at about 590 feet. and below that depth passed through a long succession of sandstones and shales with a little lime and at least one coal seam. Sandy lime increased a little with depth, and some cherty lime came in at 2786 feet. In general the well penetrated a sandstone and shale section, which could well be entirely Pennsylvanian, or at least of that age to within 250 feet of the bottom.

Cuttings from the Charles Rye No. 1 to a depth of 1775 feet were examined by M. M. Kornfeld;[13p] and cuttings from 1775 feet to 2704 feet, by another geologist. Except for traces of limestone a little below the middle, the entire Paleozoic section was shale and sandstone, described as dark-gray and dark-brown and black micaceous shale, generally non-calcareous, but slightly calcareous at a few levels, and gray indurated non-calcareous micaceous carbonaceous medium to coarse-grained quartzose sandstone. One coal seam, a little below the top of the Paleozoic (612-13 feet) appeared in the sequence, and some of the shale was coaly. No fossils were found. A core from 2675 feet showed cross-bedding and a dip of around 12 degrees. Very probably the entire section below the Cretaceous is Pennsylvanian.

No log of the Willard Rye well is available.

In the C. C. Day well the top of the Paleozoic rock was reached at 720 feet according to some reports, and Fletcher, after an examination of the cuttings, stated that the beds between the levels 900 and 4093 feet,[13c] although they contain no fossils, are unquestionably Pennsylvanian. That is, the sub-Cretaceous section is almost entirely shale and sandstone, and probably of Pennsylvanian age.

The log of the Carter Oil Company deep well near Prairie is not at hand, and for that reason any comments concerning the probable features of the section the well penetrated could be inferential only. However, one was impelled to hope, long before drilling was discontinued, that the discoveries justified the thick black veil of secrecy drawn over the face of the whole proceedings. Also some people were impelled to wonder whether or not reported local geological phenomena influenced the selection of the drilling site: such, for examples, as the reported peculiar behavior of the water in the well on the Gilmore-Evans farm, near Prairie, and the interesting character of the water of the 400-foot artesian well on the J. H. Haughton farm, near Sucatonchee Creek west of Muldon and Prairie—both described by honest, intelligent, and unimaginative witnesses. The Gilmore-Evans well, drilled by S. S. Hanks, encountered strong gas pressure at 550 feet; the water rose to within 50 feet of the top of the well, and made "heads" when gas would escape through the 500-foot column of water and burn several feet above the top of

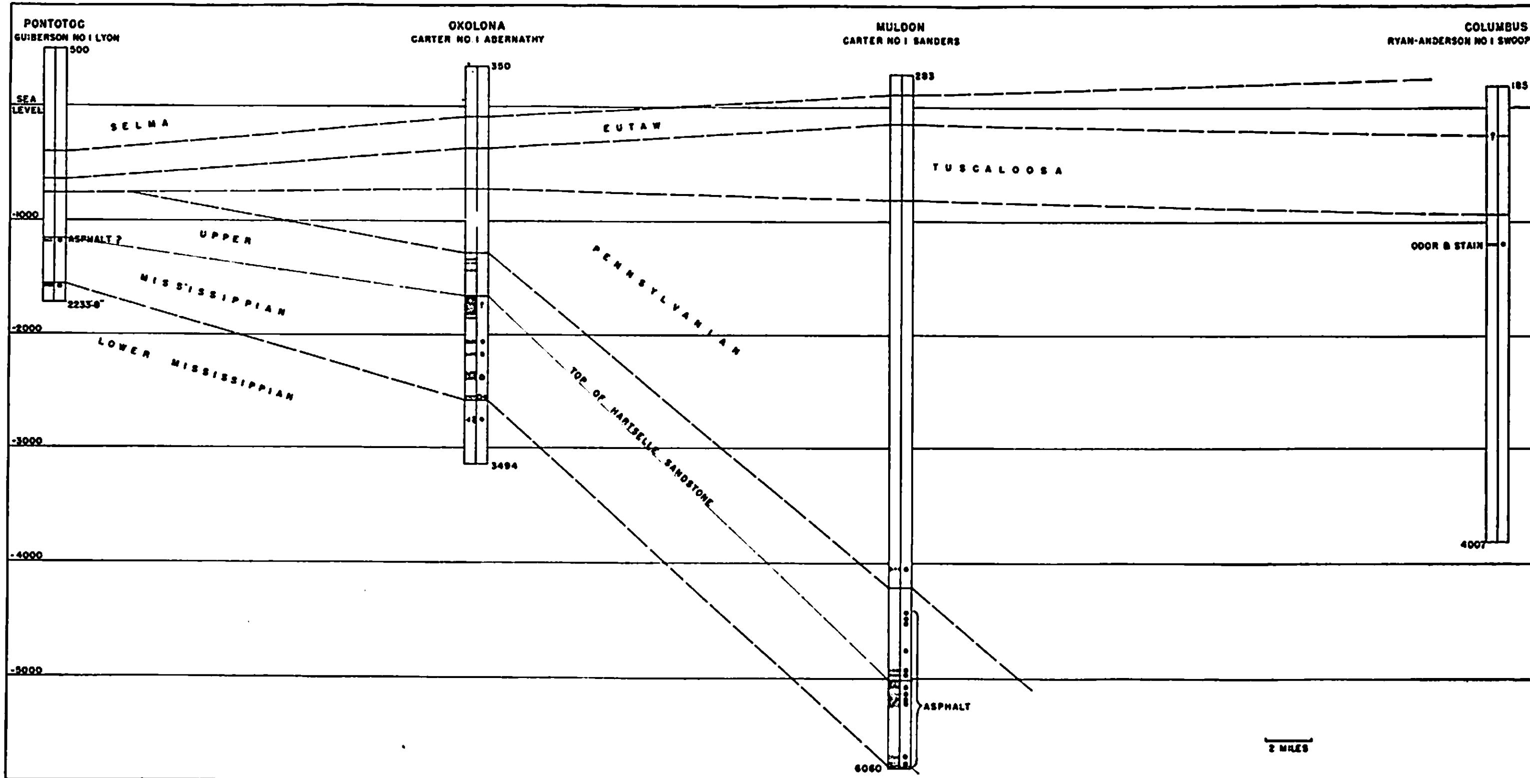

Plate 3.—Well sections and correlation of strata, showing steep dips in southwestern Monroe County. After F. F. Mellen.

the casing. A "high" was indicated here by the magnetometer. The water of the Haughton well was reported to be greasy and unfit for use; an unnamed "geologist" stated that the greasiness was due to the presence of crude oil.

Later information is to the effect that the Carter Oil Company well referred to above started at an elevation of about 283 feet above mean Gulf level, and reached the Paleozoic at 1050 feet; further, that although it reached a total depth of 6059 feet, it penetrated only 14 feet into the Iuka (Tuscumbia) formation. If this information is accurate, it points to an excessively steep dip of Paleozoic strata underlying southern Monroe County.[43] The log of the well records more than 5000 feet of Paleozoic rock from the top of the Pottsville to the top of the Iuka. Reference to the table of Paleozoic formations in this report will indicate that the total thickness of the beds of this interval as determined from outcrops and wells in northeastern Mississippi and northwestern Alabama is around 3800 feet maximum. If, then, the top of the Iuka is only 3800 feet below the top of the Pottsville in Marion County, Alabama, and 5000 feet in southwestern Monroe County, Mississippi, we must assume either a startling dip or faulting of great magnitude (Plate 3).

Concerning Plate 3, which Frederic F. Mellen kindly furnished, he states: "This cross-section is based on wells drilled at Pontotoc, Pontotoc County, at Okolona, Chickasaw County, at Muldon, Monroe County, and at Columbus, Lowndes County. The wells are almost equal distant apart and in a nearly straight line. The cross-section shows that the beds are dipping progressively steeper from the northwest to the southeast, and that the Ryan-Anderson No. 1 Swope at Columbus may be considered as lying somewhere near the bottom of the Warrior Basin geosyncline of Northwest Alabama and East Central Mississippi. The Pennsylvanian beds are for the most part dark shales and sandy shales, and, particularly in the lower part, large bodies of sandstone are developed. Locally, some of these sandstones have good porosity, but elsewhere they are hard and quartzitic. The Upper Mississippian (Chester) is composed of sandstones, shales, and limestones. The sandstones appear to be better developed toward the central part of the Basin. In Pontotoc County, in the Guiberson No. 1 Lyon the various sandstones are either missing or are represented by sandy shales or shaley limestones. There is a striking increase in the thickness of the Mississippian beds in the direction of the geosyncline which lies in the Monroe and Lowndes County area. At Pontotoc, the Chester is somewhat truncated but has a recorded thickness of 800 feet. At Okolona, this thickness is 1300 feet, or more than the average thickness of the entire Mississippian section in the outcrop area of North Alabama and Northeast Mississippi. In the Carter No. 1 Sanders at Muldon the thickness of the Chester is found to be increased to 1550 feet. The cross-section also shows the progressively steeper dip on the lower beds as the bottom of the geosyncline is approached. This is shown on all north-south cross-sections made through this area and is, also, shown by east-west cross-section constructed at the latitudes of Monroe County. Between the Carter No. 1 Abernathy, at Okolona, and the Carter No. 1 Sanders, at Muldon, there is a dip of 170 feet a mile on the top of the massive limestones of the Lower Mississippian. It is reported that seismographic work in the Monroe-Clay County area shows dips as great as 400 feet a mile."

Some general conclusions may be drawn from the facts and speculations reviewed in the preceding discussion:

1. The Paleozoic stratigraphic succession beneath the surface of Monroe County is much the same as in the outcrop areas of northeastern Mississippi and northwestern Alabama, so far as identity of formations is concerned; that is, almost all formations exposed in the outcrop areas are represented in Monroe County.

2. In general the formations thicken southward and change lithologic character southward and westward to some extent: the sections contain less limestone and more shale and sandstone.

3. Accurate correlation of the well sections is difficult because of the general absence of fossils and of distinguishing lithologic characteristics through many hundreds of feet of strata; but some layers, such as the pink shale of the Pennington and the limestone of the Bangor are of material assistance as key beds.

4. Such correlation of the well sections as is possible seems to indicate certain structural conditions which might favor oil and gas accumulation: for examples, a possible eastward dip of some Paleozoic strata in the part of the county east of Tombigbee River; faulting of undetermined magnitude in various parts of the region; and certainly a steepening of dip beginning about the latitude of Amory or a little south of it.

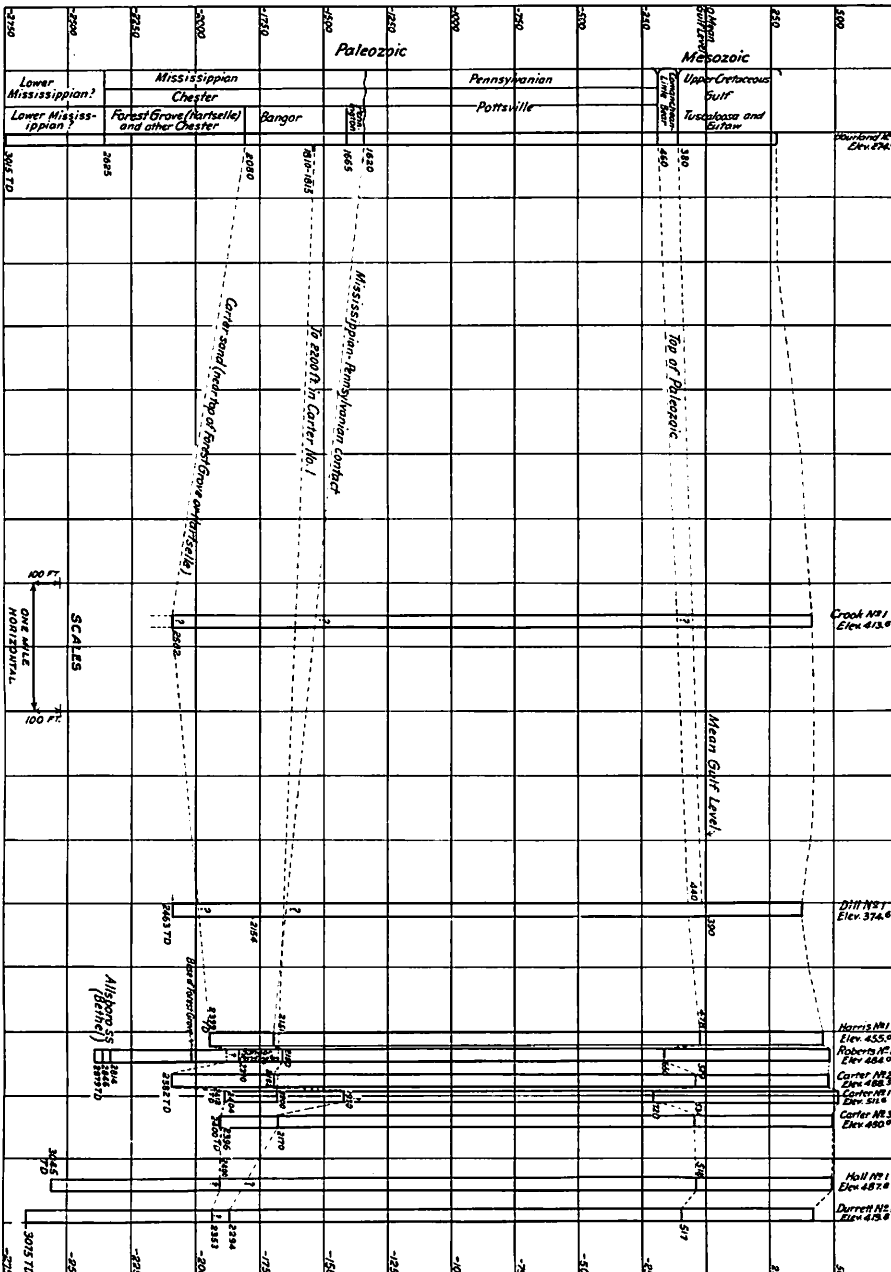

Plate 4.—Well sections showing contacts of geologic units, also depths referred to in the text, and some suggested correlations.

5. The opinion is expressed that the information available about the stratigraphy and structure of the region and about the results of drilling to date warrant the conclusion that if additional production of oil or gas is obtained in Monroe County it will be relatively small, but that the product will be of high quality (Plate 4).

BENTONITE

Bentonite is a clay-like mineral substance of somewhat uncertain origin, although most recent and efficient studies have tended to show that it is chiefly volcanic dust altered in water.[24] The Silica Products Company[25] favors a theory of the origin of bentonite which differs in some particulars from the explanation given in the preceding statement: "It appears quite probable that bentonite has been produced along with volcanic ash by the decomposition of lava or related igneous matter through the action of water. This decomposition is in some respects probably similar to that of the formation of kaolin from feldspar by the action of carbon dioxide." Although commonly spoken of as "mineral soap" or "soap clay," probably the first mineralogical name given the material was "taylorite," from William Taylor, who shipped it from Wyoming in 1888. The name "bentonite" arose from the circumstance that the material so named makes up a considerable part of the Fort Benton formation of the Laramie and Bighorn basins, Wyoming;[25] but subsequently the name has been applied to more or less similar clays or clay-like substances from numerous and widely separated localities. Ladoo[24] states, "For general purposes, perhaps, bentonite may be defined as a clay-like mineral or group of minerals consisting essentially of hydrous aluminum silicate, usually containing from 5 to 10 percent of alkalies or alkaline earth oxides. It is usually characterized by very fine grain size, high water content, high absorptive powers and high plasticity." He adds that it probably represents no mineral of fixed composition, and that its composition varies much "both in widely separated localities and also within comparatively small areas." The composition of the type material is indicated by the analyses records quoted below.[24, 25]

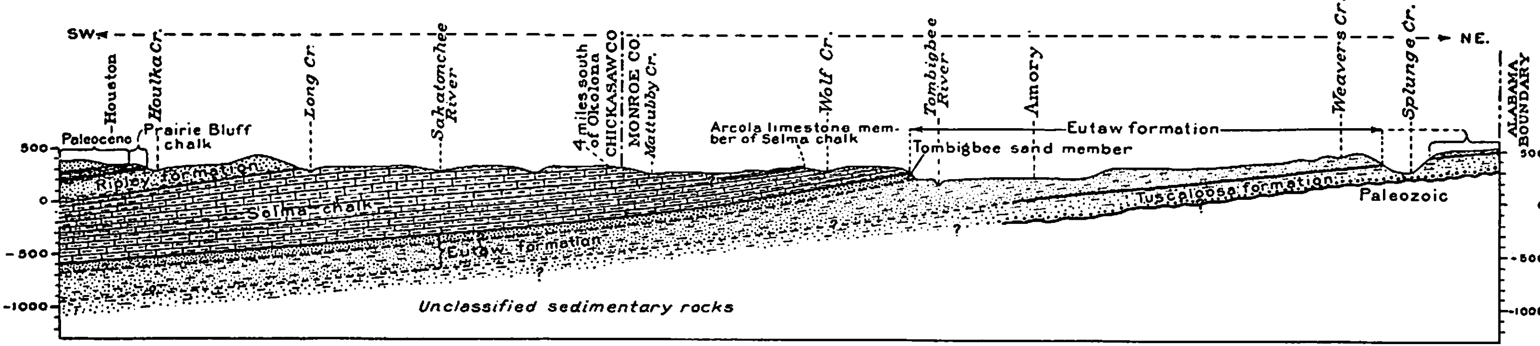

Plate 5.—Cross-section of Cretaceous formations from the Alabama boundary in northeastern Monroe County to Houston, Chickasaw County. After Stephenson and Monroe (Bull. 40, Plate 2, C-C.).

Analyses of Wyoming bentonites

	Rock Creek, Laramie Basin Percent	Silica Products Co. pits, Clay Spur* Percent
SiO_2	60.18	62.57
Al_2O_3	26.58	22.45
Fe_2O_3	-------	3.89
TiO_2	-------	-------
CaO	0.23	0.75
MgO	1.01	2.46
K_2O	1.23	-------
Na_2O	-------	0.80
SO_3	-------	0.30
CO_2	-------	-------
Cl	-------	0.20
P_2O_5	-------	-------
Ignition loss	-------	6.18
H_2O	10.26	-------
Totals	99.49	99.60

*Dried for 5 hours at 105°C.

The analyses records of some Mississippi bentonites quoted on succeeding pages illustrate further the wide variation in chemical composition, but all consist essentially of hydrous aluminum silicate and alkalies or alkaline earth oxides, as stated. The formula $Al_2O_3.4SiO_2.xH_2O$ perhaps expresses the average composition of bentonite fairly accurately. The alumina may be partly replaced by iron, lime, or magnesia, or by alkalies; chemically combined water rarely exceeds 2, although water of combination may range from 1 to 15.[25]

The physical properties of bentonite, for the most part outgrowths of or closely related to the chemical composition of the material, make possible a diversity of uses. The chief physical properties[24] may be summarized: Color ranges widely; the type material is light-yellow to greenish-yellow, but bentonite may be cream-colored, white, gray, pink, dark-brown, blue, green, or black, as tinted by the impurities present, especially iron oxide and carbonaceous matter. Texture is important: bentonite is exceedingly fine-grained, or colloidal; the particles are much smaller than those of ordinary clay,[25] so small, in fact, that individual grains can be distinguished only under a high-power microscope; so examined, they are seen to be fairly uniform of size, and more or less rounded. The luster of bentonite is waxy and shiny on a surface made by a fresh cut, although the common appearance is dull and powdery; a fresh, unweathered piece of bentonite feels extremely smooth and soft, and when wetted feels like soft soap; the fracture of the fresh material is commonly roughly conchoidal, but may be platy and shale-like. Special properties which are marked in the type bentonite and commonly are present to a greater or lesser degree in all clays which can properly be called bentonites or are closely related to them, are high absorptiveness and plasticity, low fusibility, and the property of allowing replacement of the alkaline and earth oxides one with another. Very remarkable absorptiveness is attributed to some bentonites and is held by some authorities to be distinctive of true bentonite: capacity to absorb more than three times their weight of water and seven times their volume, is claimed to have been noted, and expansion when wetted to six to nine times their original volume. Capacity to gel is characteristic of many bentonites: when finely ground and thoroughly stirred with not less than ten times their weight of water, they form a translucent gelatinous mass and remain in suspension indefinitely.[24] Indeed, the Silica Products Company contends that true bentonite must have this capacity to gel: "typical bentonite, when dried and mixed with two percent of magnesium oxide, will form a stiff gel in the presence of twenty-five times its weight of water."[25] The company considers bentonite possibly a mixture of the hydro-gels of silica and alumina. Increasing the hydroxylions, as by the addition of sodium hydroxide (Na OH) or magnesium oxide (MgO), enhances the tendency to gel.[25] Plasticity varies widely among different bentonites: in the type material it is very high, but in some other grades may be very low or non-existent. Fusibility is low in all true bentonites. Furthermore, the minerals of the bentonite groups have the property of allowing easy replacement of the alkaline and alkaline earth oxides, one with another. This property may affect the physical properties of the bentonites, and is utilized in softening hard water.[24]

The uses of bentonite are so numerous that a complete list can not be given here. In fact, bentonite probably is utilized for more different purposes than any other mineral substance. Authorities mention not fewer than fifteen to twenty different lines of manufacturing or other industry which use it extensively, and each of these uses it in a number of different branches or phases. A few of the more important uses may be mentioned:[24 25] As a bleaching agent for oils of all kinds probably is the most extensive use of bentonite,* a use which may be made possible by the presence of H and OH radicles adsorbed in a thin layer on the surface of the clay particles: these, driven off by heat, leave open bonds which remove the darker constituents from the oil.[26] Bentonite is used for other purposes also in connection with petroleum production and refining: as a drilling mud, as a de-watering agent for crude petroleum, as a binder for chemicals in vapor phase treating of gasoline. Perhaps its second most important general use is in foundry work, as a bond for molding sands, and as an ingredient in core-washes to keep carbonaceous material in suspension. Also, it is used in hydraulic cements and plasters: in Portland cement it improves plasticity and workability, hastens setting, and increases strength; in gypsum plasters it acts as a retarder. Bentonite is used in the ceramics industry as a suspending agent in pottery glazes, and for other purposes; in the paper industry as a filler and for other purposes; in emulsions it is used extensively; and in engineering as a sealing agent for reservoir walls, dikes, dams, etc.[24] All the various uses of bentonite are made possible by its peculiar physical properties, particularly its extreme fineness of grain, its extraordinary affinity for water or other fluids, its remarkable smoothness and freedom from grit, its high plasticity in some cases, and the property which permits the easy exchange of alkaline and alkaline earth oxides one with another.

The bentonite of Monroe County, except for one or two small deposits, is scattered over two relatively narrow belts, one in the eastern part of the county, the other in the central (Plate 1). The eastern belt trends a little east of south across the northeastern corner of the county in the hill country west of Splunge Creek and roughly parallel with it. No deposits of consequence have been found south of the latitude of Gattman or east of Splunge Creek. The middle bentonite belt parallels Tombigbee River, all accumulations being on the west side. Stratigraphically, the bentonite is in the Tuscaloosa and Eutaw formations. The easternmost of the deposits, near the eastern edge of the Splunge Creek belt on the Jones or Gilliland property, is above the lignitic clay and sand zone which marks the top of the Tuscaloosa.

*It may be pertinent to mention here that the Wyoming bentonite, which the Silica Products Company maintains is the only true bentonite, is not a good bleaching agent.[25]

Within these two belts, bentonite is found on a number of properties:

Eastern belt, the Tuscaloosa and Eutaw formations

Frank Glass	Sec. 14, T. 12 S., R. 17 W.
Frank Fears	Sec. 8, T. 12 S., R. 9 E.
Frank Durrett	Sec. 23, T. 13 S., R. 17 W.
Pauline Huff	Sec. 23, T. 13 S., R. 17 W.
Waldrop Bros.	Sec. 34, T. 13 S., R. 17 W.
Old Gordon Place (Crews)	Sec. 23, T. 13 S., R. 17 W.
B. F. Thomas	Sec. 26 T. 13 S., R. 17 W.
Tribble Bros.	Sec. 33, T. 13 S., R. 17 W.
Lawyer Kelly	Sec. 33, T. 13 S., R. 17 W.
C. M. Harrison	Sec. 10, T. 12 S., R. 9 E.
C. M. Harrison	Sec. 11, T. 12 S., R. 9 E.
Pine Dimension Co.	Sec. 14, T. 12 S., R. 17 W.
S. J. Collier	Sec. 24, T. 12 S., R. 17 W.
P. T. Hodo	Sec. 14, T. 12 S., R. 17 W.
P. T. Hodo	Sec. 23, T. 12 S., R. 17 W.
Charlie Cox	Sec. 10, T. 12 S., R. 17 W.
H. Blair	Sec. 35, T. 13 S., R. 17 W.
G. B. Gilliland	Sec. 13, T. 12 S., R. 17 W.
T. R. Gilliland	Sec. 14, T. 12 S., R. 17 W.
N. L. Lawson	Sec. 14, T. 12 S., R. 17 W.
Mrs. Latchie Jones	Sec. 24, T. 12 S., R. 17 W.
V. E. Downs (Filtrol Corp.)	Sec. 10, T. 12 S., R. 17 W.
M. S. Ray (Filtrol Corp.)	Sec. 14, T. 12 S., R. 17 W.

Central belt, the Tombigbee member of the Eutaw, and possibly partly basal Selma

Ebb Meeks	Sec. 4, T. 14 S., R. 7 E.
Wise	Sec. 4, T. 14 S., R. 7 E.
Alice Strong	Sec. 12, T. 15 S., R. 7 E.
Early Duke	Secs. 12 &13, T. 16 S., R. 7 E.
B. F. Johnson	Sec. 13, T. 16 S., R. 7 E.
Henry Hogan	Sec. 12, T. 16 S., R. 7 E.
Wesley Meeks	Sec. 4, T. 14 S., R. 7 E.
James Keaton	Sec. 13, T. 16 S., R. 7 E.
T. A. Bradley	Sec. 13, T. 15 S., R. 7 E.
Perel and Lowenstein (American Colloid Co.)	Sec. 25, T. 15 S., R. 7 E.

The northernmost of these deposits, on the property of C. M. Harrison (Secs. 10 and 11, T. 12 S., R. 9 E.), underlies a north-south ridge for at least 0.5 mile, and crops out in two or three places in ravines. During a recent prospecting of this property 40 or more holes were bored, ranging in depth from 49 feet to 5 feet and distributed pretty uniformly over the area. The bentonite is blue or pale greenish yellow, rusty in places. The considerable range of thickness (a few inches to nine feet) found by the test holes may be due in part to uneven original deposition, but probably has come about chiefly since deposition, through weathering and creep.

The C. H. Cox bentonite (Sec. 10, T. 12 S., R. 17 W.) was discovered several years ago. On the basis of a very few prospect holes some time in 1934 or 1935 Mr. R. V. West of Tulsa, Oklahoma, estimated the tonnage of good clay at 200,000 to 250,000 (dry), based on an average thickness of five feet and 1200 tons per acre-foot. Later and more thorough prospecting proved a much greater tonnage and the presence of additional deposits.

Holes bored by the present survey penetrated thicknesses of 3.3 feet, 4.5 feet, 5.0 feet and 6.0 feet of bentonite; the overburden is 40 to 50 feet except in a few places. The property is a mile or more by a rough farm road from the nearest public road, which is gravel. The Mississippian Railroad reaches Smithville a few miles west. The property is at present under lease by Eastern Clay Products, of Eifort, Ohio.

This bed of bentonite crops out here and there in the west wall of Weaver Creek valley for 0.5 mile or more. The material is greenish to whitish, or yellow to brown, and breaks out in lumps bounded by conchoidal surfaces. The V. E. Downs and Lindsey properties (Sec. 10, T. 12 S., R. 17 W.) adjoin the Cox property, and the same deposit of bentonite underlies them and crops out in places. Prospecting by the Filtrol Corporation on the Downs and Lindsey properties is said to have discovered thicknesses of 9 to 10 feet or even more of good clay.

The greater part of the bentonite in the eastern belt is in Sections 13, 14, 23, and 24, Township 12 South, Range 17 West, on the Frank Glass, Pine Dimension Company, Collier, Hodo, G. B. Gilliland, T. R. Gilliland, N. L. Lawson, Mrs. L. Jones, and M. S. Ray properties. This area includes some of the highest hills of northeast Mississippi, overlooking the valley of Splunge Creek on the east. In fact, bentonite is scattered through a succession of roughly north-south ridges in this region; it makes up several deposits, some of which no doubt were connected at one time. Very considerable thicknesses have been discovered by prospect drilling, and the aggregate tonnage must be very great. On the Frank Glass property, for example, borings found 5 feet of bentonite in one hole, 9 feet in another, and in two others penetrated thicknesses of 12 feet and 9 feet without having reached the bottom of the bentonite bed. Most of the bentonite here is waxy and cream-colored, but two holes found blue bentonite. The overburden ranges from heavy to light, maximum about 35 feet, but average around 25; it is Eutaw brown sand containing some shaly sand rock and a little hard ferruginous sandstone. Some holes located a little above the bentonite level failed to find any of the clay, and one, on the Glass property, a few feet too low, penetrated dark to black stiff clay at a depth of 11 feet. The Glass property is on the Brock School gravel road a mile and a quarter from the Detroit and Amory road.

On the old Gordon place, known also as the Crews place (SW. 1/4, Sec. 23, T. 13 S., R. 17 W.), about 1.5 miles north of Greenwood Springs, a small pit dug several years ago on an outcrop a few yards from a tenant house found a bed 2.3 feet thick of a brownish-gray to greenish-gray, very smooth waxy brittle bentonite. The bed had a steep dip: a hole less than 100 feet down dip from the pit encountered the same bed at a depth of 12 feet. A hole up dip from the pit a few yards, on top of the hill, reached bentonite at a depth of 20.5 feet, and penetrated only 1.2 feet of it. Very probably, then, the steep dip of the bed exposed by the pit is due to slumping; this seems all the more likely because the pit is located on a steep slope near the head of a ravine, and the dip of the bentonite is parallel to the slope. The greater thickness of the bed in the pit over that in the hole only a few yards distant updip probably is due also to the measurement at a rather high angle to the bedding; that the bed is the same is obvious from the fact that bentonite was found in the hole at a depth only slightly less than the elevation of the mouth of the hole above the pit. However, the bentonite from the pit has certain characteristics—unusual weight, high density, some degree of induration, darker green color, and others—which seem to suggest slight metamorphism which has given it some of the characters of metabentonite; these together hint that the deposit may be on a fault line. The dip may, then, be due to large-scale faulting rather than to local slumping.

Several holes were bored on this same property on spur ridges across the heads of ravines from the tenant house. The greatest thickness of bentonite found was 2.7 feet, under overburden ranging from 4 to 17 feet of sand with a little clay and sand rock. Apparently only a small quantity of bentonite is present on the old Gordon property, but both blue and pale yellow were found.

On the Mrs. Latchie Jones property (Sec. 24, T. 12 S., R. 17 W.) a small outcrop of pale greenish-yellow bentonite in the steep east wall of a valley tributary to Splunge Creek valley led to the discovery some years ago of a considerable deposit. A hole (P 36), bored by the present survey a little above the outcrop, penetrated 5.5 feet of good bentonite, but 1.5 feet of the brown sand overlying it contained fragments of bentonite, indicating a greater thickness elsewhere under more favorable conditions for protection against weathering. A second hole (P 37), a little lower, found 7.0 feet of bentonite much mixed with brown clay and sand. The overburden of Eutaw sand, sand rock, and a little clay or clay shale is 60 feet thick above the outcrop, and the slopes steep. One of the seven holes on the E. C. Crow property about 300 yards east of the Jones outcrop, on the same hill, found 2.8 feet of sand-contaminated bentonite. The hole was located on the slope, and for this reason probably did not penetrate the full thickness of the bentonite on this property. The Jones and Crow bentonite is near a good gravel road, 9 to 10 miles by road north of the Frisco Railroad at Greenwood Springs, but, as stated, the overburden is heavy. No doubt this bentonite is part of a single large deposit with the others located in the Splunge hills, and while possibly not connected with them now, probably was at one time.

An intensive survey by Frederic F. Mellen,[27] Consulting Geologist, of 20 acres of land (W. 1/2, W. 1/2, E. 1/2, SW. 1/4, Sec. 14, T. 12 S., R. 17 W.), the property of Pine Dimension Company of Columbus, Mississippi, discovered bentonite ranging in thickness from less than a foot to 17.9 feet. The prospecting was carried on along the west side of the Brock School road for a distance of slightly more than 0.5 mile; 22 holes were bored, starting at elevations ranging from 459.0 to 420.0 feet above mean Gulf level, and penetrating in most cases to a few feet below the bentonite or the bentonite level, but all the bentonite was found in the holes starting from 448.0 to 432.5 feet. Mellen estimated the quantity at 46,000 cubic yards, which, on the basis of 3,000 pounds per cubic yard, estimated weight of the clay in the ground, would be 69,000 short tons or 61,607 long tons. The overburden reaches a maximum thickness of about 25 feet. The Pine Dimension Company deposit probably is fairly representative of several bentonite accumulations in this region, as stated on a foregoing page. The conditions for working are fair: overburden is not excessive, and consists of the usual sand and sand rock of the Eutaw, but the location is not easily accessible, being in perhaps the highest part of the county, not all parts of the gravel road are good at all times, and the place is several miles from the nearest railroad. The bentonite is said to be of excellent quality.

The Frank Fears bentonite (SW. 1/4, Sec. 8, T. 12 S., R. 9 E.) is farther west than any other deposit east of the Tombigbee, and the only deposit found in the terrace areas. The clay underlies the east wall of the valley of a small tributary of Bull Mountain Creek, and crops out in one place in the floor of a gravel pit on the north side of a local road. Fourteen holes were bored by the survey on the Fears property, borings being made on both sides of the valley, but progress was so difficult because of heavy gravel beds overlying the bentonite that most of the holes could not be carried to the level of the bentonite bed. The gravel where the pit was opened is 20 to 25 feet thick. No bentonite was found west of the valley, and the greatest thickness penetrated was 1.9 feet, of which 0.7 foot above was pale greenish-yellow almost white, and 1.2 feet below was blue and sandy. This bentonite is on a good gravel road in a flat region, and appears to be of good quality, but is small in quantity, so far as prospecting to date has discovered. The overburden, too, up to 25 feet of gravel, conglomerate, and sand, would be very troublesome to any effort to reach the clay. Possibly more intensive prospecting, especially on the west side of the valley, might find greater thicknesses, but the almost impenetrable gravel and conglomerate would make prospecting very laborious. The bentonite on the Fears property seems to lie almost on the Tuscaloosa-Eutaw contact, about 12 feet above the lignitic sand and clay bed.

A large body of bentonite, exposed by Panther and Little Panther Creeks and their tributaries in the dissected Tombigbee bluffs a mile west of the river and 4 to 6 miles south of Aberdeen, has the distinction of being the first bentonite in Mississippi to be described in any publication.[28] It underlies parts of Sections 14, 23, 24, 25, and 26, Township 15 South, Range 7 East, and former properties of N. W. Dahlem, Fred Dahlem, Bank, Johnson, Sykes, and possibly others. Grim[28] reported two distinct beds, each having a thickness of 4 to 7 feet, interstratified with the Tombigbee green sand of the Eutaw formation. However, later thorough prospecting by Dr. Poole Maynard,[29] for Perel and Lowenstein of Memphis, who had 960 acres purchased or leased, showed only one bed "of importance," the so-called "upper." Prospect pits 4 to 5 feet in diameter and totaling 657 feet in depth, and 4-inch borings totaling 2,403 feet, showed thicknesses from about 0 to 9 feet, an average of 5.6 feet being used in estimating the tonnage. Bay[30] reported a "lower bed" thickness of 11 feet on the N. W. Dahlem property, consisting of 6 feet of dark bluish-gray material below, and 5 feet of massively bedded greenish-gray hard and waxy somewhat arenaceous bentonite above. Vestal and Mellen found only one bed, 6 to 6.5 feet thick. The total tonnage proven by the Perel and Lowenstein survey was more than 500,000, on the dry basis (74.20 pounds per cubic foot), and estimates of another 500,000 tons have been made. Yellow bentonite and blue bentonite were recognized, the former being an oxidation phase of the latter: below local water-level the material is blue to nearly black; above water-level, yellow. In the area prospected, the blue bentonite had a uniform thickness of 6 to 8 feet, and contained 30 percent moisture. The bed dips westward some 20 feet to the mile. The overburden is, in general, heavy, ranging from 15 to more than 100 feet of compact sand, unconsolidated except for a few layers. Maynard maintained that underground mining was feasible, and recommended that method of digging the bentonite as most economical.

The deposit is readily accessible: an all-weather gravel road extends along the bluff just above the clay area, and the town of Aberdeen, on two or three railroads, is only about 5 miles distant.

The American Colloid Company of Chicago, for several years back, have been using the Panther Creek bentonite as a source of supply for their plant located at the intersection of the Illinois Central Railroad and a local road 1.7 miles south of the main street of Aberdeen, and 4 miles or a little more north of the deposit (Figure 11). The digging operations are carried on along a narrow belt of creek toward both valley walls to a lateral distance determined by the thickness of the overburden. In some places the clay has been cut out by the stream in its meanderings (Figure 12). The overburden is removed by a "bulldozer" where it is not too thick,

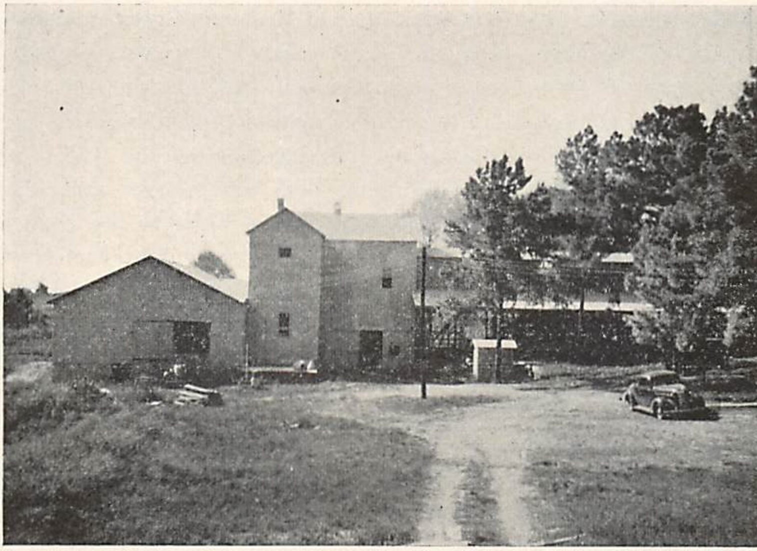

Figure 11.—Bentonite plant of the American Colloid Company, 0.5 mile south of Aberdeen on Strongs road. July 31, 1942.

Figure 12.—Bentonite pit of the American Colloid Company, on Strongs road, 6 miles south of Aberdeen. July 31, 1942.

and pushed back out of the way, into areas from which the bentonite has been removed. The workable bed, 8 to 9 feet thick, consists of two types of the clay—blue, and light yellow to cream colored. A dark layer 8 to 10 inches thick crops out towards the top of the bentonite, and some bentonite mixed with the sand above this seems to indicate creeping or sliding on the slope. After the overburden is removed, the bentonite is dug by pick and shovel and loaded directly into the trucks, which haul it up the bluff to the road and to the plant. Each truck carries 2 to 2.5 cubic yards, each mined cubic yard probably weighing some 2,500 pounds, each unmined cubic yard approximately 3,000 pounds. Some time ago the clay was raised to the top of the bluff by a hoist, along a narrow track, but that method was abandoned when a way was found to permit the trucks to get down to the pits.

At the plant the truck is driven onto a runway, and the load of bentonite is dumped to a floor below, under a shed, from where it is fed into a crusher and crushed to pieces of 0.5 inch in size. The clay then passes through a revolving cylinder or conduit in which it is subjected to a "flash" of heat of 1200 degrees F.; the actual temperature of the furnace reaches 1800 degrees at times. Natural gas is the fuel used. The clay, dried to 2.5 percent moisture, is then ground to a size which will pass a 200-mesh screen; of course it is ground to different degrees of fineness for different purposes and to suit different customers. The finished product is sacked in asphaltic-treated sacks to prevent taking up of moisture. Some Wyoming and Nevada bentonite is imported to be mixed with the Mississippi clay or used in filling orders rceived at the western headquarters for this material to be sent to customers in the South. The company, in an advertising booklet, claims for "Panther Creek foundry bentonite" several desirable properties: Very high green strength; moderate dry strength; easy shake-out—no lumps; high permeability; high sintering point; excellent flowability. It is said to mix readily with sands containing other clays, and that less temper water is needed because the bentonite has very high green strength when the sand has a very low moisture content. It is "used to revive dead sand; to make other clays in the sand more effective; to make new synthetic sand; to make strong, collapsible green sand cores."

When the plant is operating at capacity, the output is about 2.5 tons of finished product per hour. About 25 men are employed under the direction of Mr. Acord, Superintendent. The product is shipped over a wide territory, and used for many different purposes.

In addition to the main deposit described above, the American Colloid Company has bought or leased other bentonite deposits, of which the best known are the T. A. Bradley and the Alice Strong properties. The Alice Strong property was formerly known as the Auzzie Macbeth place (Sec. 12, T. 15 S., R. 7 E.). The bentonite lies at various levels below the top of a low terrace which borders the flood plain of Tombigbee River some 2 miles southeast of Aberdeen; perhaps it is at no place at a greater elevation than 15 to 20 feet above the river flat, and some of it may be at flood plain level. Prospecting by the present survey and recent more extensive prospecting by other parties have discovered great irregularity in thickness and distribution of the bentonite on this property. For example, one hole above a small outcrop 30 yards or so south of the road which leads to the house penetrated 4 feet of light-yellow to whitish bentonite, but a second hole, not more than 50 yards farther south and 13 to 15 feet above the first, found nothing but sand to a depth of 17 feet, a depth insufficient to reach the bed in case of a steep dip. Of the seven holes drilled, three penetrated bentonite: 3 feet of blue bentonite, 4.5 feet of grayish, and 4 feet of pale yellow respectively; but four holes found only sand, chiefly brown and yellow. The greatest overburden was 19 feet, above the blue bentonite, which was underlain by blue sand. The results of prospecting by other parties indicate that the bentonite bed or beds and associated strata have been much faulted and eroded, so that the bentonite now present consists of patches at different levels. The conditions here suggest landslips and landslip topography.

On the Wesley Meeks property (Sec. 4, T. 14 S., R. 7 E.), 4 1/2 miles north of Aberdeen, a small deposit of hard white waxy bentonite lies some 15 to 20 feet under the tops of the ridges, in the Tombigbee sand, probably within 30 to 40 feet of the base of the Selma. The bed is said to have a maximum thickness of 2.5 feet and an average of 1.5,[30] but the greatest thickness found by the eight holes bored by the present survey was 1.5 feet. An outcrop in the steep wall of Mill Creek channel shows a maximum thickness of 1.7 feet. Where the bentonite is free from sand it is of good quality; but the light overburden has permitted rather extensive weathering, and the upper part of the bed is perforated with sand-filled mollusc (teredo?) borings to such an extent that the sand has reached almost every part of the deposit.

Small bodies of bentonite have been found in the Tombigbee green sand on the west side of Tombigbee River in a number of places south of the large deposit which is worked by the American Colloid Company. These may have been connected at one time. The small deposits on the W. E. (Early) Duke property (Secs. 12 and 13, T. 16 S., R. 7 E.), about a mile north of the Monroe-Clay county line, are good examples. The bentonite shows in the floor and west wall of the channel of a small tributary of the Tombigbee. The larger of the patches is farther upstream, perhaps 300 yards above a farm road bridge. As seen in the outcrop, the material is rusty, jointed, and broken by conspicuously curved fractures into rounded lumps. In fact, the bentonite from this place affords one of the best examples of conchoidal fracture the writer has seen: not only do masses break from the bed as rounded lumps, but each lump will separate into tenacious concentric shells. The material is blue when fresh, and notably silty. The outcrop shows a thickness of 3 feet, but a 29-foot hole a few yards distant at the top of the left bank of the stream 24 feet above the outcrop found sand only, and another hole 250 yards farther down stream likewise failed to find bentonite. Thus, the evidence seems to indicate that this bentonite is only a small pocket. The other showing on the Duke property is a very thin seam in the right wall of the creek channel perhaps a quarter of a mile below the larger deposit. All the bentonite of this vicinity appears to be interbedded with sand or with a very sandy clay shale or silty sand, black-blue and very micaceous.

In the west wall of Tombigbee River channel at Bartons Bluff, Clay County, almost opposite the mouth of Buttahatchie River, a stratum of bluish-gray to greenish bentonitic clay extends along the bluff for a considerable distance. The material is hard, tough, silty, and micaceous, and breaks with a pronounced conchoidal fracture, rounded lumps made up of concentric shells showing prominently in the much jointed and fractured bed. The body varies in thickness, but the maximum is not more than 4 feet. The bed lies a few feet above a hard layer of Eutaw green sand, and is sapped back somewhat beneath a loosely indurated sand which in places is jointed and separated into blocks. At least three indurated layers are exposed in the bluff here. The bentonite is only a little below the Eutaw-Selma contact.

No deposits of bentonite of commercial size have been found south of the American Colloid Company pits, but small lenses here and there seem to indicate a definite bentonite zone extending for long distances in the Tombigbee sand west of the river.

Chemical analyses of Monroe County bentonites are given in the "Tests" part of this report. Maynard[23] quotes the record of an analysis of the Panther Creek bentonite by the Barrow-Agee Laboratory of Memphis as follows:

"Analysis of yellow bentonite, Panther Creek area Monroe County

	Percent
SiO_2	55.45
Al_2O_3	17.68
Fe_2O_3	6.82
CaO	1.43
MgO	2.63
Moisture loss at 100° C.	8.26
Further loss on ignition	7.82
Total	100.09."

It will be seen from a comparison of this record with the analyses records of the "type" bentonites of Wyoming, as quoted on a foregoing page, that the Mississippi material runs much lower in silica and alumina, and higher in ferric oxide, calcium oxide, and magnesium oxide, also higher in ignition loss. In general, too, the Mississippi bentonite slakes and crumbles in water, but does not swell; possibly this may be due to the high percentage of free silica it contains. Its chief mineral is montmorillonite. Tests have shown that much of the Monroe County bentonite is a good bleaching clay, in spite of its failure to come up to the U. S. Geological Survey standard for bleaching clays, and that some of it is satisfactory as a bond for molding sand. The American Colloid Company plant ships it to customers over a wide territory for use for a number of different purposes. But the Wyoming people would not class the Mississippi clay as bentonite, but as a rather low-grade bleaching clay; they insist that the only true bentonite is the Wyoming type, which is not an effective bleaching agent.[25]

The bleaching efficiency of a clay is measured in terms of "ratios of volumes of oil filtered to the volumes of clay used in filtering." These ratios, called "bleach ratings," are expressed by numerals. "In most tests, ratios are given for the first appearance of green, yellow, red, and black colors. For example, 1.5 in the column headed Gr. in a bleach rating means that 1.5 inches of bleached oil (water-white) passed through one inch of clay before the appearance of the green color."[30]

The ranges of lowest limit of bleach allowable for commercial application, according to the U. S. Geological Survey laboratory, are: Naturally active clay (raw): Gr. 0.7; Yel. 0.9; Red 1.0; Bl. 1.2; activable clay (acid-treated): Gr. 1.4; Yel. 2.0; Red 2.4; Bl. 2.9.[30] The bleach ratings of some Monroe County bentonites are listed below:

From Panther Creek vicinity, old N. W. Dahlem property, later Perel and Lowenstein and American Colloid Company: From lower bed, upper part, raw clay, Gr. 0.4, Yel. 0.5, Red 0.5, Bl. 0.5; acid-treated, Gr. 1.0, Yel. 1.6, Red 1.7, Bl. 1.7; from lower bed, lower part, raw clay, Gr. 0.0, Yel, 0.1, Red 0.1, Bl. 0.1; acid-treated, Gr. 1.1, Yel. 1.6, Red 1.7, Bl. 1.7;[30] from horizon not specified, raw clay, Gr. 0.4, Yel. 0.5, Red 0.5, Bl. 0.5; acid-treated, Gr. 1.6; Yel. 2.1, Red 2.3, Bl. 2.4; Fe:Al:Ca::3:6:1;[26] from horizon not specified, raw clay, Gr. 0.2, Yel 0.3, Red 0.3, Bl. 0.4; acid-treated, Gr. 1.4, Yel. 2.0, Red 2.2, Bl. 2.4; Fe:Al:Ca: :4:5:1.[26]

From Wesley Meeks property, raw clay, Gr. 0.3, Yel. 0.4, Red 0.4, Bl. 0.4; acid-treated, Gr. 0.8, Yel. 1.4, Red 1.6, Bl. 2.1.[30]

From Gordon old place, known also as Crews place, north of Greenwood Springs, raw clay, Gr. 0.4, Yel. 0.5, Red 0.5, Bl. 0.5; acid-treated, Gr. 1.4, Yel. 1.9, Red 2.5, Bl. 2.8; Fe:Al:Ca::4:5:1.[26]

From C. H. Cox property, raw clay, Gr. 0.5, Yel. 0.6, Red 0.6, Bl. 0.6; acid-treated, Gr. 1.9, Yel. 2.0, Red 2.1, Bl. 2.2; treated, 25 percent off.[26]

If the U. S. Geological Survey standard for bleach ratings is applied, the Monroe County bentonites are found wanting as bleaching clays; but none the less Filtrol Corporation has leased or bought large deposits, presumably for use as bleaching material.

SAND AND GRAVEL

Sand is very abundant in Monroe County; in fact, as has been brought out in the discussion of stratigraphy, sand is the material of the greater part of the Tuscaloosa formation; of almost all the Lower Eutaw; of all the Tombigbee member of the Eutaw except for a little bentonite and clay; of a considerable part of the Selma, and of a very large proportion of the Pleistocene and Recent formations. It surely would seem that from this immense body, sand for any purpose could be taken, and it is true that satisfactory structural sand for both building and paving is available in the county. Indeed that could hardly be otherwise, inasmuch as in many cases specifications are written to fit supplies available in each locality.[31] In almost any part of the county east of the Tombigbee, sand which would serve some purpose could be dug from the roadside; and that sand from such sources has been used in the past is attested by a few small sand-pits. Probably, good molding sands could be found, too; the specifications for molding sand would seem to permit the use of material of a kind which appears from observation and simple tests to be present in large quantities in Monroe County. Of the two general classes of molding sand—that with natural bond and that without natural bond[31]—the former would include most of the Tuscaloosa and Eutaw sands, which almost invariably are clayey or silty and contain iron oxide. They would be classed as "foundry sand," "iron molding sand," or simply as "molding sand," to distinguish them from the "silica sand" or "steel molding sand," which is more highly refractory and is without natural bond. As the names indicate, the sand which has the natural bond is used commonly for molding cast iron and the nonferrous metals or alloys, such as brass, whereas the sand which has no natural bond is used for steel molding.[31] Of course the value of a sand for foundry purposes depends not only on bond, or cohesiveness, but on permeability, grain size, refractoriness, and durability;[31] and the question of whether or not all these properties in any particular sand meet requirements, would have to be answered by tests. It is unlikely that any clean silica sand is present in the county, but if it should be, a good bond, bentonite, is near at hand. None of the sand could be used for the manufacture of fine glass, either, because of the impurities, especially iron oxide; but possibly some of it would be suitable for green or amber glass.[31]

Very probably quantities of Monroe County sand suitable for one or more of the numerous other uses to which sand is put, could be found if adequate search, including tests, were made; but sand is so very abundant almost everywhere that no considerable commercial development could be hoped for unless a deposit of very high-grade sand usable for some special purpose were discovered. No such material has yet been found, and in view of the character and mode of genesis of the rock formations, probably does not exist. A limited, more or less local utilization, then, is the best that can be reasonably anticipated.

Gravel also is very abundant in Monroe County. By far the greater part of it is in the terraces along Tombigbee and Buttahatchie Rivers, but it makes up a considerable proportion of the Tuscaloosa formation, as has been stated. The alluvium of the flood-plains is chiefly sand and gravel. The Eutaw contains a little small gravel at certain horizons, too. Although small gravel pits have been opened in several places in the county, most of them, and all the large gravel plants, are located near the Tombigbee, and get gravel from the terraces or the flood-plain.

Recently, enormous quantities of gravel and sand were used in the construction of the huge Gulf Ordnance plant near Prairie by the Ferguson-Oman Company. For months fleets of trucks were speeding along U. S. Highway 45 E south of Aberdeen to and beyond Buttahatchie River, and on local roads east and west of the highway, picking up gravel and sand from numerous pits newly opened in the terraces which feature the topography in this region, and rushing them to the construction job, while at the same time other material was being rushed to Aberdeen and Muldon by train, and trucked to the scene. The pits are in places too numerous to mention, but a few of them are of considerable extent. Washed sand and gravel are drawn from gravel plants near Amory and Aberdeen. The mixed material direct from the pits is used for metaling roads and for filling depressions; the washed gravel is used for concrete aggregate chiefly, the washed sand for mortar and plaster.

The Amory Sand and Gravel Company (J. T. Sanford and E. L. Puckett)[7b] operates a large plant at Bigbee, on the Frisco Railroad and on State Highway 6, 2.5 to 3.0 miles northwest of Amory. The plant consists of two barges and machinery, and screening buildings and equipment. The alluvial material and water are sucked from the bottom of the pit through 10-inch suction pipes by Amsco centrifugal counter-flow pumps powered by electric motors; forced through 8-inch discharge pipes to the top of the 30-foot screening crib, from where they fall through a series of screens which separate the gravel from the sand and silt and assort the gravel into different sizes. The water, carrying the silt and some sand and fine gravel, returns to the pool via a shallow wooden trough or sluice. The screened and washed gravel and sand are dumped into trucks which are driven underneath the screens, and hauled away to where they are to be used, or they are piled in a stock pile west of the plant, to be drawn on as needed. Three sizes of gravel are marketed: the coarse road gravel, the concrete coarse aggregate, and the pea gravel. The screens used have openings of 3/8-inch, 3/4-inch, 1-inch, and 1.5-inch. The full capacity output is about 25 to 30 cars a day; most of it is used for railroad ballast or concrete aggregate. For concrete aggregate a considerable amount of sand is required.

The sand is run through a series of screens with square openings; the results in percentages are about as tabulated below:

0 - 5	retained on No. 4 screen
10 - 55	retained on No. 16 screen
70 - 90	retained on No. 50 screen
95 - 100	retained on No. 100 screen.

The finer sand is sold as mason sand and the coarser as concrete sand. Some years ago a stretch of about 5 miles of road from Amory towards Smithville was blacktopped with sand and tar alone as an experiment, chiefly because the sand cost practically nothing, whereas crushed gravel cost around $1.20 per cubic yard.

Some time back, when most of the output was shipped by rail, a spur extended from the nearby railroad to the plant. Gondola cars were run under the screen chutes, loaded, moved forward to the main line, and shipped. Now, however, almost all the gravel and sand are trucked away. A very large proportion of the recent output was used in the building of the Ferguson-Oman Gulf Ordnance Plant west of Aberdeen.

The pit has been excavated to a depth of 25 feet or more along an old slough from Tombigbee River, and is connected with the river channel. The gravel as a body is cross-bedded below, horizontally bedded above, and somewhat iron-stained; the pebbles range in size from a maximum of 4 to 5 inches in diameter down to "torpedo gravel" and smaller. All pebbles are more or less rounded.

Mineralogically, they are chiefly chert, but some quartz pebbles are present, and some conglomerate and sandstone was encountered in the digging of the pits. The overburden consists of 8 to 10 feet of mixed gravel and sand and 1 foot to 2 feet of gravelly and sandy subsoil and soil. The supply of gravel here is very great, and the location for shipping good.

The Amory Concrete Gravel Company, headed by P. M. Hollis of Amory, has a plant located a little beyond the northwest edge of Amory, on the south side of Highway 6, on the flood-plain of Tombigbee River. The pits occupy a considerable area, and the supply

Figure 13.—Amory Concrete Gravel Company plant, about 0.8 mile west of Amory, on south side of U. S. Highway 41. June 24, 1942.

of gravel is very great. The output is washed gravel for concrete aggregate; it has amounted to 100 carloads per week at times. A few years ago much if not all of the output was taken by the Mississippi State Highway Commission for the building of roads, one of which was the highway east from Tupelo. Electric power for the operation of the pumps and shovels is provided by the Tennessee Valley Authority. The gravel is sorted by screens into many different sizes for use for different purposes. The Highway Commission is very insistent on having for a certain use gravel of a uniform size; the smaller sizes are favored for concrete.

The Amory Concrete Gravel Company has a plant (Figure 13) on the south side of State Highway 41 about 0.8 mile from the city limits of Amory. A pit about 75 to 100 yards long by 40 to 50 wide has been excavated here in the west face of the terrace or second bottom on which Amory stands, or, rather, in the southeast wall of a shallow valley through the terrace. An engine, on a barge in the pool, runs a pump which raises water, gravel, and sand from the gravel beds below water level to the top of the screen crib, whence the water, sand, and gravel descend through the screens. The water and much sand flow away in a sluice and are returned to the pool; the remainder of the sand, containing considerable grit and very small gravel, is retained on the screens, and is later removed by truck and piled on the hill up slope from the plant. Only about two sizes of gravel are used—the small gravel, 0.5 inch or less in diameter, is screened out, and all the remainder, including pebbles from largest to smallest, is thrown together. The material was used for making concrete in the construction of the Gulf Ordnance Plant west of Aberdeen (Ferguson-Oman Company).

Logan's[32] records of granularmetric analyses of some Monroe County sand and gravel are summarized in percentages below:

1. Gravel from terrace face on Cotton Gin Port Road, about 3/4-mile southwest of Amory.

Sieve	Retained	Passed
1.5-inch-mesh	00.0	100.0
1.0-inch-mesh	22.0	77.9
0.5-inch-mesh	23.4	54.5
1/16-inch-mesh	14.0	40.5

2. Gravel from outcrops on Stockton farm, Smithville Road, 4 miles north of Amory

Sieve	Retained	Passed
1.5-inch-mesh	00.0	100.0
1.0-inch-mesh	11.1	88.9
0.5-inch-mesh	40.6	48.3
1/16-inch-mesh	32.0	16.3

3. Gravel from river bar between Bigbee road bridge and Frisco Railroad bridge over Tombigbee River northwest of Amory

Sieve	Retained	Passed
1.5-inch-mesh	16.2	83.8
1.0-inch-mesh	7.1	76.7
0.5-inch-mesh	20.3	56.4
1/16-inch-mesh	42.4	14.0

4. Sand from river bar between Bigbee road bridge and Frisco Railroad bridge over Tombigbee River northwest of Amory

Sieve	Retained	Passed
16-mesh	01.5	98.5
20-mesh	00.3	98.2
40-mesh	8.5	89.7
60-mesh	71.4	18.3
80-mesh	16.0	2.3
100-mesh	0.1	2.2.

Logan[32] states that the Amory terrace is composed of clay and loam above, 8 to 10 feet thick, and gravel below, 12 to 20 feet thick. Well records in the vicinity of the Stockton farm show 10 to 20 feet of gravel, he says. The river bar gravel was used for concrete aggregate and the sand for plaster.

The Francis gravel plant is located on the Tombigbee 1.2 miles south of State Highway 6 at Bigbee (NE. 1/4, Sec. 35, T. 12 S., R. 7 E.). The pit is excavated in the flood-plain. The gravel is covered deeply with sand except in the river channel, where gravel bars form rapids at low water. Three or four washing and screening sheds 25 to 30 feet high are standing, but only one is in operation at present. Gravel is obtained from the river channel, washed, and hauled away by truck. The washed gravel is a mixture of sizes.

CERAMIC CLAYS

Clay makes up part of all three geologic formations which crop out in Monroe County, but the considerable bodies of pure or relatively pure clay are confined to the Tuscaloosa. As indicated in the descriptions of the Eutaw and Selma, the clay in these formations is either intimately mixed with the other materials, or is aggregated in the form of very thin beds, laminae, lentils, or nodular masses, more rarely as thicker lenses of compact jointed clay or clay shale.

In the Eutaw formation the clay is everywhere sandy; in the Selma terrane it is very limy as well as sandy.

As stated in the description of the Tuscaloosa, the formation is mainly sand, but contains gravel, clay, and lignite. Much of the clay has been aggregated in the form of lenses of various sizes, or irregular masses, and in a few beds which maintain a fairly uniform thickness under sizeable areas. A persistent zone of lignite and lignitic sand and clay lies at or a little below the Tuscaloosa-Eutaw contact, and was penetrated by a number of holes. In fact, most of the clay outcrops belong to this zone, and most of the test hole samples were taken from it. A few of these deposits are briefly described here.

Near Gattman, which is on the Frisco Railroad, on the A. C. Kelly property (SE. 1/4, Sec. 32, T. 13 S., R. 16 W.), a way for Highway 6 was made by cutting away the north end of a ridge which forms part of the south wall of the wide valley of Buttahatchie River. The steep face of this cut shows beds of clay below and sand and mantle above. Mr. Kelly, who is the railroad agent at Gattman, made some measurements of the clay exposures about the time the cut was completed, when accurate measurements were possible—that is to say, when the terrane was dry and hard, and slides had not yet developed. He determined the length of the outcrop of white and mottled clay at the base of the cut to be 352 feet, and its maximum thickness, in the center, to be 8.5 feet. Above this light-colored clay are 3 to 4 feet of bluish or slate-colored clay, dark, apparently somewhat lignitic. Mr. Kelly stated further that perhaps a quarter of a mile farther west, holes on the slope above the highway found the same white clay, and that, a mile still farther west, on Highway 6, two wells sunk on his place a short distance south of the highway encountered the white clay, one at 16 feet, the other at 11.5 feet. One of the wells was dug 4 feet into the clay, the other 14 feet, but neither reached the bottom of the light and mottled clay. These wells were about 200 yards apart and on slightly different levels. The present survey bored one hole (P 60) on the ridge above the outcrop at Gattman, and another (P 61) a little south of Highway 6 about a mile and a quarter west of Gattman. The Gattman hole was about 30 feet higher than the hole farther west, and found 22 feet of clay; the other hole penetrated 21 feet of clay, but in general the logs of the two holes were not similar.

Mr. Kelly stated that he sent samples of the white clay to the State Chemist for analysis and tests, and that the State Chemist reported that the clay was the best he had received from anywhere in Mississippi. Some was sent also to the Smithville Pottery Company, who made good stoneware of it. Locally it has been used with success for whitewash, and for filling up cracks in the plaster walls of houses.

The Gattman clay seems to be part of a very extensive deposit. West of the big cut, the highway crosses the head of a small valley, west of which, in the vicinity of the wells referred to, the top of the dark clay shows at the base of the wall of another road cut, almost a mile from Gattman; a third exposure can be seen along the road leading south from Gattman. Probably, too, it could be profitably worked, at least over a limited area near Gattman. Although the beds dip westward at a low angle, the position of the top of the clay is in general above the ground surface in the valley head referred to above—that is, the valley has been cut into the clay; but if the clay is as thick everywhere in this vicinity as is indicated by the holes and by the evidence given by Mr. Kelly, much of the bed, particularly the white clay, should underlie the valley bottom, unless erosion preceded filling to a marked degree. On the west side of the valley head the blue clay shows by the roadside.

As already stated, this material is on a good highway and also on a railroad. Much of it approaches a kaolin in properties. If thorough testing should prove it to be suitable for a variety of ceramic uses, the Gattman clay might be a fair commercial venture.

Clay on the Dyer property, near the Suggs pottery, long had the reputation of being the best pottery clay of a very considerable territory. The Suggs pottery used this clay for some time, getting it from a nearby deposit which crops out in the floor and bank of a small tributary of Bull Mountain Creek 200 to 300 yards west of the pottery. In the pit, the clay is laminated and light gray, in a bed 4 to 5 feet thick containing some thin hard layers, and overlain by gravel. The clay itself contains some pebbles and considerable fine sand. The potters considered the Dyer clay excellent for stoneware, but finally discontinued its use, largely because of the gravel in it. Some idea of the areal extent and the thickness of the clay in this vicinity may be obtained from the records of twelve holes bored by the present survey on the Dyer and Francis properties. Total thicknesses of clay penetrated by these holes ranged from 1.5 to 26.0 feet, including in one hole a single bed of stiff gray clay 16.0 feet thick under only 10.0 feet of sand and gravel; in another, 14.4 feet of brown and gray clay split by two 1.0 foot beds of sand, under less than 4.0 feet of soil, clay, and gravel; and in a third, 15.3 feet of gray, brown, and blue clay under 6.3 feet of gravel and sand. The greatest unbroken thickness, 22.5 feet of dark-gray sandy clay, was penetrated within a few feet of a fault-plane, where the beds are dipping at a high angle (Figure 9). The holes were strung along the valley of the branch referred to above for a distance of around 0.5 mile, but most of them were near the upper end of this stretch, in the vicinity of a road bridge. All this clay probably is suitable for one type or another of ceramic products. The area is readily accessible, being between two local roads and only 0.5 mile from the Smithville-Tremont highway 3 miles from Smithville. However, the water-table is only 8 to 12 feet below the surface in many places, and a little back from the valley the overburden is greater and consists in large part of gravel and conglomerate.

In the hill slopes and valley bottoms of the eastern part of the county, outcrops of Tuscaloosa clay are numerous; and along the public roads, these outcrops determined the locations of the test-holes. The map (Plate 1) shows how widely the borings were scattered over this region. At many of the places large quantities of clay could be dug after the removal of relatively light overburden. A few of the more favorable localities may be described briefly.

Some of the clay used by the Smithville pottery which suspended operations several years ago, was dug from the outcrop on Johnson hill, described on a preceding page. Where the pit was, pretty well towards the bottom of the hill, the bed of gray slightly lignitic iron oxide-stained clay is about 5 feet thick, part of a series of beds including sand and ferruginous sandstone units. In fact, as described in the section, all the material here is sandy, and is overlain by sand; the Smithville potters became dissatisfied with the clay, saying that it contained too much sand, making it too porous for their use, so that the glaze would not stick. This probably is the Johnson farm deposit described by Logan[33] as a gray plastic clay which may be used in the manufacture of stoneware. Logan's test-record may be summarized:

Physical properties:

Plasticity: 20 percent of water required
Air shrinkage: 8 percent

Firing tests:

Cone 17: Color, light yellow; hardness, vitrified
Cone 20: Hardness, unfused; in flame, incipient viscosity; absorption, none; total shrinkage, 16 percent

Loss of weight in burning, 4 percent.

Ten holes (P 17 - P 21 and five others) by the present survey on the Johnson property found 10 to 12 feet of clay, all sandy, and greater thicknesses of sand or clayey sand. Although the deposit is on a good gravel road 4 miles east of Smithville and therefore accessible, digging of the material would be difficult and expensive, because of heavy overburden a short distance back from the foot of the hill, and because of much sand and sand rock within the clay.

On the same road (Smithville and Pikeville) 3 miles farther east by south (NW. 1/4, Sec. 8, T. 12 S., R. 10 E.) an outcrop of 2 to 3 feet of gray, iron-stained clay was noticed in the walls of the road cut a little west of the Coker Store. Test hole P 15, started a little above this outcrop, penetrated 5.5 feet of dark-blue clay under 14.3 feet of overburden, chiefly sand, and 30.5 to 41.0 feet in depth passed through a blue clay which turns greenish on exposure to air; probably it is montmorillonitic. The overburden here is moderate over a small area. The clay in this vicinity may be the same which Logan[33] reported as two beds of stoneware clay in the public highway near Fox's (Cox's?) Store, a lower interbedded with red sand at the foot of the hill east of the store, and an upper, overlain by red sand, near the top of the hill west of the store. He suggests that because of the presence of some pyrite these clays should be weathered for several months before being used. Logan's statement of the results of his study of these clays so confuses tests of samples from one bed with tests of samples from the other, that only a general summary can be ventured:

Physical properties:

Plasticity: 25 percent to 28 percent of water required
Air shrinkage: 12 percent
Particle size: Less than 1 percent retained on 150-mesh screen
Rate of slaking: Slow

Tensile strength: 75 pounds per square inch average for wet molded briquettes; 111 pounds per square inch for air-dried briquettes

Firing tests:

Cone 13: Hardness, vitrifies

Cone 17: Color, cream; hardness, vitrified (upper clay)

Cone 20: Hardness, unfused (upper clay); total shrinkage, 16 percent to 17 percent; absorption, none

Loss of weight in burning: 5 percent to 6 percent

A mile farther east on the Smithville and Pikeville road in the east wall of the valley of Splunge Creek, are thick clay outcrops (Holes P 8, P 9, P 10, P 12), and in the vicinity of Oak Hill School and along the Detroit road up to 2 miles southeast of the school, clay appears in several places (Holes P 1 - P 7). An unusual feature of the clay of this region is the thin very light gray to white beds which crop out in the ravines some 0.5 mile east of the school. These appear to be very good kaolinitic clays, but are thin where found; possibly more extensive prospecting would discover greater thicknesses. On the Oak Hill School-Detroit road, Hole P 2, a mile southeast of the school, penetrated 28 feet of unbroken clay beds, and Hole P 1, a mile farther southeast, passed through 22.6 feet of successive clay beds. The area around P 1 is the more favorable for working, so far as overburden is concerned.

On both sides of the Amory-Detroit road, and in both walls of Weaver Creek valley, but especially in the east wall, outcrops of light-gray to dark-gray and brown to black Tuscaloosa clay are prominent (Sec. 22, T. 12 S., R. 17 W.). Test hole P 40 was located on the east side of the valley, south of the road, and P 41 on the west side, north of the road. The former penetrated, under 13 feet of soil and sand, 21.6 feet of clay strata, except for 1.2 feet of lignite. In the same slope, some 0.3 mile farther north, 3 to 4 feet of dark-gray to almost black clay show in an old road cut; the clay is underlain by sand. Conditions in this area are only reasonably favorable for development operations; near the highway the overburden would interfere with economical excavation, but over a small tract in the vicinity of the outcrop north of the highway the overburden is relatively light.

A mile or so northwest of Splunge school, test hole P 32 was bored on the east side of the Amory-Detroit road, above an outcrop

(Sec. 25, T. 12 S., R. 17 W.). This hole passed through thicknesses of 4 feet and 10 feet of clay interbedded with sand and sand rock. Hole P 33, about 100 yards farther northwest, and 30 feet higher, penetrated 17.7 feet of sand, sand rock, and beds of clayey sand or sandy clay, under which was a 7-foot water-bearing sand; below this, 13.3 feet of yellow, blue-gray, and blue-black clay. The topography of a considerable area here would not offer any serious obstacle to digging operations, but water might be troublesome. The lower hole (P 32) is about 75 feet above Splunge Creek.

Figure 14.—Tuscaloosa strata in the walls of a cut for a local road near the site of Testhole P 46 (Sec. 12, T.13 S., R.17 W.). July 11, 1943.

The Isom Faulkner property (Sec. 35, T. 12 S., R. 17 W.), 1.5 miles southwest of the locality just described, is not easily accessible, but test holes P 38, P 39, and two others found considerable thicknesses of clay, and the topography is fairly favorable for digging, at least over small areas. Hole P 38, on a low ridge near the Faulkner home, passed through 23 feet of overburden, chiefly sand, and a succession of beds of which 10 feet were clay and 4 feet lignite. Hole P 39 found a succession of clay strata totaling 21 feet under only 10 feet of overburden. The Faulkner land is in a small valley and the clay crops out in a place or two near the base of moderate slopes; conditions appear favorable, then, for the removal of large quantities from the lower margins of the valley walls and from the valley flat, in case erosion has not already cut much of it away in the valley itself. Water might have to be reckoned with.

Test holes P 43, P 44, P 45, and P 46 (Figure 14), west of Splunge, penetrated some beds of apparently good clay, but for the most part thin. The light-gray mottled clay found by P 43 and P 44 crops out in the walls of a road cut and gullies 0.5 mile west of Splunge; hole P 43 found 5.7 feet of it and P 44 more than 9.0 feet, but some sand rock and sand were interbedded with the clay in P 44. Conditions here are favorable for working the clay deposit: overburden is negligible in several acres at least, drainage is good, and the location is on a fairly good gravel road near other better roads and a village. The quantity of usable clay is uncertain, of course; an outcrop and two test holes provide insufficient data on which to base an estimate, but clay is known to be fairly abundant all through this region.

Other localities north of Mississippi State Highway 6 which appear promising are the L. Guyton property (Sec. 17, T. 13 S., R. 16 W.), and the J. W. Ray property (NE. 1/4, Sec. 30, T. 13 S., R. 16 W.). Test holes P 47, P 47 bis, P 48, and P 49 were bored on the Guyton land, where white clay had been discovered some time before. P 47 found 3.0 feet of white clay and 1.5 feet of yellow clay; P 47 bis, 5.0 feet of bluish-white and 3.0 feet of yellow, and P 48, 8.5 feet of sandy gray clay. The holes were located in the walls of a small valley a little above the valley flat; overburden is heavy unless the clay is present under the flat to a greater extent than the holes seem to indicate.

The clay of the J. W. Ray property crops out in roadside gullies in the north wall of the valley of Buttahatchie River a short distance west of the Ray residence. Test hole P 50, on a low ridge above the eastern of the two outcrops, found 12.9 feet of clay, in two beds interbedded with white, gray, and yellow sand. This clay was light gray with some yellow, and a sample taken from the outcrop a few yards north of the hole was light gray to dull white and somewhat sandy. Hole P 51, about 100 yards northwest of P 50, and approximately the same elevation, passed through three or four thin beds of clay, the thickest 2.3 feet, all interbedded with sand. The lowermost interval was 31 feet of water-bearing sand.

The conditions for development here are favorable so far as overburden and location on a good gravel road are concerned, and the clay appears to be of good quality; but the total quantity of clay may not be large, the several sand beds would be difficult to separate from the clay beds, and the water from the underlying sand probably would interfere with work. The place is 2 to 3 miles from the Frisco Railroad at Gattman.

Logan[33] mentions an "outcrop of gray clay in the public road about one mile west of Quincy." He gives the exposed thickness as 6 to 8 feet, under an overburden of cross-bedded micaceous sand. The present survey could not locate this place with certainty, but about a mile and a half west of the village, and probably 150 yards east of the Frisco Railroad, gray clay-shale crops out in a road cut, a thickness of 3 to 4 feet being exposed; this may be the place referred to by Logan. The overburden is not great here. A second outcrop of like character shows north and east of Quincy— dark-gray clay, stained with iron and containing small lumps of red ocher—and other small showings may be seen here and there in the vicinity, but most of the territory is sand of shades of yellow, brown, and red. Logan's verdict is that the Quincy clay can not be used except in the manufacture of brick and red earthenware. His statement of the results of his tests is tabulated below:

Physical properties:

Plasticity: 26 percent of water required

Air shrinkage: 16 percent

Rate of slaking: rapid

Firing tests:

Cone 13: Hardness, completely fused in flame

Cone 17: Color, red (in muffle); hardness, swollen, cracked (muffle)

Loss of weight in burning: 10 percent

General: Clay will not receive either slip clay or artificial glaze.

Logan[33] states also that on the Dean place 2.5 miles north of Greenwood Springs station is a 12-foot bed of blue Tuscaloosa clay underlain by lignite, and that this clay can be best used for light-colored unglazed ware. Hole P 53 of the present survey, on the hill slope along the road west of the Walter Dean house, reached a depth of 45 feet, penetrating clay beds totaling 13 feet or more in thickness, and three black strata. Conditions are not favorable for digging this clay. Logan's test-record is summarized as follows:

Physical properties:

- Plasticity: 23 percent of water required
- Air shrinkage: 12 percent
- Rate of slaking: rapid
- Tensile strength: 84 pounds per square inch

Firing tests:

- Cone 17: Hardness, vitrified without cracking (in muffle); shrinkage 4 percent; total shrinkage, 16 percent
- Cone 20: Color, dark blue; hardness, vitrified, unfused, incipient viscosity
- Loss on ignition: 3.5 percent

General: Raw clay takes slip glaze poorly.

South of Mississippi State Highway 6 in the eastern part of the county, Tuscaloosa clay crops out at many places, and twenty-five holes were bored in this region along the public roads. Unfortunately, although clay of good quality and thickness was found, most of it is under heavy overburden except in narrow belts along hill slopes, and some localities are not easily accessible. Along Wolfe Road from Highway 6 south for 4 miles, test holes (P62 - P 69 and others) penetrated clay and sand strata, but at no place could a large quantity be economically moved. Perhaps the best area is along the old section of Wolfe Road a little south of the highway. A small area along State Line Road about a mile south of Gattman has some features favorable for working the underlying clay, which was found by test hole P 58 to total 13 feet or more in thickness, but to be in three or four beds separated by sand strata. Hole P 59, about 0.8 mile farther south, penetrated more than 18 feet of clay, but is located on a rather steep slope.

The "pinkish-white" clay noticed by Logan[33] on the L. M. Nix farm, eastern part of Section 3, Township 15 South, Range 17 West, was not found by the present survey, but in the road cut a little south of the Nix residence, about 2 feet of gray and red mottled clay which weathers light-colored, are exposed. This is plastic and only slightly sandy; probably it would make good stoneware. Mr. Nix stated that a well dug in the slope a little northeast of his house, on the opposite side of the road, encountered clay at 16 feet and continued in it 12 feet deeper without reaching the bottom of the bed.

The present survey also failed to find the clay which Logan[33] locates 1 mile north of the Lowndes County line and 3 miles west of the Mississippi-Alabama state line; it was equally unsuccessful in its search for the outrcrop which he locates in the public road 0.5 mile north of the Nix farm. However, a number of small outcrops were seen along the various local roads. Logan calls all these Tuscaloosa white clays.

Aside from the bentonite plant south of Aberdeen, the only clay industry at present in operation in Monroe County is the Suggs pottery (Sec. 34, T. 11 S., R. 9 E.), some 2.5 miles east-northeast of Smithville and 0.5 mile or less south of the Itawamba County line. And at this writing the clay used by this pottery is hauled from land purchased in Alabama. A few years back, however, the clay used was obtained near the pottery, on the Dyer land, as already stated. The plant is small but well equipped, and turns out good stoneware. The clay to be used is first thrown into a well-built brick pit or bin, from which it is fed into the pug-mill. The kiln has a capacity of a few hundred gallons; the ware is sold locally, for the most part, largely through peddling. The one wheel is powered by motor.

Until recently a pottery was operated near the center of the village of Smithville (Sec. 6, T. 12 S., R. 9 E.). The Smithville Pottery was probably as widely known as any pottery in northeastern Mississippi. Mr. Mills and his son owned the plant and superintended the work, and Mr. Mills senior was the leading turner. The plant did not differ materially from other potteries of the region. The clay was ground in a pug-mill by mule-power; after grinding, it was kneaded by hand and cut into lumps, each of which contained sufficient material for the making of the object for which it was intended—churn, jug, jar, or flower-pot. Churns and jars of various sizes were the chief types of ware manufactured. Only one wheel, and this of the "kick" type, was operated. The ware, fresh from the wheel, was placed on shelves to dry before it was stacked in the kiln for burning. The kiln, built of brick, was fired with wood. The

Smithville pottery tried out clays from many different localities in the region, but of course the purchase price of the raw material and the expense of getting it to the plant were primary considerations. The ware was disposed of by peddling or by sale at the plant; perhaps some little was shipped.

At the time of the Logan survey, two Amory companies were manufacturing brick from clay obtained from the Tombigbee second bottom on which the town of Amory stands. The clay pit of the L. H. Tubb Brick Manufacturing Company[34] showed 7 feet of bluish and reddish jointed clay beneath 1 foot of sandy soil and 3 feet of yellowish loamy clay and underlain by 5 feet of sand and gravel. The Park Hotel in Amory was built of brick made by the Tubb plant. Logan's statement of the record of chemical analysis of the loam clay and of the results of his study of the properties of the jointed clay is summarized below:

Physical properties, raw clay:

- Plasticity: 14 percent of water required
- Air shrinkage: Total, raw, 6 percent; with 10 percent coal, 6.66 percent; with 10 percent cinders, 5 percent
- Tensile strength: 100 pounds per square inch
- Tensile strength: with 10 percent coal, raw, 150 pounds per square inch
- Tensile strength: with 10 percent cinders, 155 pounds per square inch

Firing tests:

- Absorption: 11.86 percent in soft-burned stages
- Tensile strength: Burned, 220 pounds per square inch; burned with 10 percent coal, 273 pounds per square inch; burned with 10 percent cinders, 300 pounds per square inch.

Rational analysis:

- Clay substance: 23.45 percent
- Free silica: 56.86 percent
- Fluxing impurities: 9.10 percent

Chemical analysis:

> H_2O, 5.20 percent; volatile, 5.10 percent; SiO_2, 71.04 percent; Fe_2O_3, 7.92 percent; Al_2O_3, 9.27 percent; CaO, 0.87 percent; MgO, 0.31 percent; SO_3, trace.

The C. C. Camp[34] brick plant obtained its clay from a pit near the other plant; the stratigraphic section was similar. At the Camp plant the clay was molded in a stiff-mud machine of the auger type; a double-bar die and an automatic end-cut machine were used. The brick were burned in rectangular up-draft kilns.

The Amory Brick Company, which suspended operations a few years ago, was a division of the Abrams Company, Forest and Clay Products, of which Mr. W. C. Abrams is president and general superintendent. The raw material from which the brick were made was dug at the plant, which stands on the Amory terrace or second bottom of Tombigbee River. The gray jointed clay used is said to be 18 feet thick in places and to underlie a large area, as proved by wells 500 yards apart reaching the clay at about the same depth. The blue clay found by the excavation for the Frisco Railroad underpass, half a mile or less northwest of the brick plant, may be part of the same body. In addition to a good brick the clay made a good drain tile and hollow tile.

In the winning of the clay for brick-making, the overburden of sand and soil was not rejected, but went into the mix, serving to give the necessary openness, or porosity. The customary brick-plant machinery and processes were used. Two kilns received the bricks to be burned: one up-to-date down-draught beehive type of 147,000 capacity, and one of the old style oblong or box type. When the plant was operating full capacity, its output was about 20,000 4 3/4-pound bricks per 10-hour day; but work could not be continued through the winter, due to lack of closed drying buildings.

The company has been in business for 18 years, but the operations of the clay products division were suspended several years ago, and before that time were carried on at irregular intervals and for longer or shorter periods, as economic and weather conditions determined. The market was local, chiefly. Evidence seems to be conclusive that the Amory Brick Company turned out a good product; resumption of the manufacture of these bricks should be encouraged.

Logan[34] described briefly the clay pit section of the old Aberdeen Sand-Lime Brick Company, in the second bottom of Tombigbee River. Joint clay, bluish in places, showed 7 feet thick in the walls of this pit. The data he gives are summarized below:

Physical properties, joint clay:

Plasticity: 17 percent of water required when mixed with 10 percent of coal

Air shrinkage: Total, 10 percent; with 10 percent coal, 6 percent; with 10 percent cinders, 6 percent

Tensile strength: 87 pounds per square inch in raw state; 140 pounds per square inch with 10 percent coal; 175 pounds per square inch with 10 percent cinders

Firing tests:

Absorption: 12.24 percent in burned briquettes with 10 percent coal
Loss of weight in burning: 11 percent in being water-smoked and burned; 10 percent in burning with 10 percent coal

Tensile strength: 263 pounds per square inch burned with 10 percent coal; 300 pounds per square inch burned with 10 percent cinders.

Rational analysis:

Clay substance, 23.07 percent; Free silica, 60.41 percent; fluxing impurities, 8.88 percent.

Chemical analysis:

H_2O, 4.95 percent; volatile, 4.92 percent; SiO_2, 71.13 percent; Fe_2O_3, 7.75 percent; Al_2O_3, 9.12 percent; CaO, 0.42 percent; MgO, 0.63 percent; SO_3, 0.08 percent.

The clay west of Tombigbee River is residual from weathering of clayey and silty chalk, or is transported, composed of the same kind of weathered material which has been moved by water or by soil creep, commonly only short distances. Most of this clay contains lime, either finely divided and widely disseminated, or in the form of concretions or nodules; and as a rule it contains some iron sulphide and iron oxide. Much of it is high in carbonaceous matter.

Colors range from black to white, through dark-gray, light-gray, brown of various shades, and yellow of various shades; mottling is very common. In general the clay is more limy westwards, and less sandy and silty; however, the residual clay from any one part of the chalk area is pretty much of the same appearance as that from any other part of it, as a comparison of the logs of the test-holes will show. The thicknesses of the mantle of residual clay vary greatly, of course, from place to place, in keeping with the changing conditions of weathering, but the maximum thickness probably is not much in excess of 10 feet. Inasmuch as the chalk region has a rolling topography, the overburden is not great at any place, and no high steep hills would interfere with digging and transportation; the water-level, too, is normally low, but in rainy weather local unmetaled roads are almost impassable. This last factor is not important, however, because of the wide extent and rather uniform character of the clay, which make available numbers of favorable places for development. Under the circumstances, if the material is usable at all, that which is located favorably with reference to population centers and travel and transportation routes would be given first attention. So far as the writer has been able to determine, this residual clay has not been used in Monroe County, but many years ago a brick plant was operated at Nettleton, Lee County, only a short distance north of the northern boundary of Monroe. As described by Logan,[34] the materials used belonged to a surface deposit consisting at the bottom of a fat jointed clay containing sandy streaks; above, a sandy layer; at the top a yellowish loam. The total thickness of the surface deposit was about 20 feet, but of course the plant pits did not reach this depth. No particulars were given concerning the chemical composition of the clay or its behavior under fire.

The black clay, which crops out in numerous places in the eastern part of the county, was penetrated in most of the holes in that region and has, for a long time, been an object of much interest to progressive citizens, who have sent many samples to various laboratories for testing and analysis. Some of the records of the results of examinations made of samples submitted by Mr. C. M. Harrison are summarized below. The work was done by the Robert W. Hunt Company, of Chicago.[35]

Chemical analysis

	Percent
Moisture (loss at 105° C.)	3.71
Silica (SiO_2)	56.21
Total iron calculated to ferric oxide (Fe_2O_3)	3.17
Aluminum oxide (Al_2O_3)	26.83
Titanium oxide ($Ti\,O_2$)	0.77
Calcium oxide (CaO)	0.60
Magnesium oxide (MgO)	0.51
Sodium oxide (Na_2O)	0.39
Potassium oxide (K_2O)	0.09
Combined water—some carbon dioxide	6.31
Carbon	1.54
Total	100.13

The pyrometric cone equivalent, or fusion point, is given as 31 - 32, which, the Technical Director states, is equivalent to a temperature exceeding 3055° F. He adds that this high fusion point would classify the clay as a refractory of the "high heat duty brick" grade, and probably is due to the high aluminum oxide content and the relatively low calcium and magnesium oxides and iron and alkalies. Inasmuch as the clay burns to a buff color, he says, it is his opinion that the dark color of the raw clay is due to carbon. He observes that the clay is quite plastic, and somewhat difficult to work unless mixed with other clays, and expresses the opinion, therefore, that mixing with less plastic clays should aid in its handling in the making of ceramic products. The company report on this clay continues: "We are submitting a small brick burned from an equal part of clay and burned clay. This brick was heated to a temperature of approximately 2700° F. and held for three hours at 2500° F. This test was made to determine the color when burned under oxidizing conditions and also its ability to resist heat at 2500° F. In our opinion, this material would be classified as 'Ball Clay.' Since this material has a fusion point above 3000 it would be classified as a fire clay. The term fire clay is employed rather loosely and is not confined only to refractory clays. Any stoneware clays are often included with fire clays. Mississippi is not generally recognized as a producer of fire clay. We are surprised that a clay of these properties has not been exploited."

Samples of a white or very light-gray clay which underlies the black clay in many places (See logs of test-holes and descriptions of sections) were studied by the same laboratory.[35] The results are stated in the following:

Chemical analysis	Percent
Moisture (loss at 105° C.)	2.26
Silica (SiO_2)	57.08
Iron, calculated to ferric oxide (Fe_2O_3)	3.74
Aluminum oxide (Al_2O_3)	25.06
Titanium oxide (TiO_2)	0.96
Calcium oxide (CaO)	0.03
Magnesium oxide (MgO)	0.67
Sodium oxide (Na_2O)	0.24
Potassium oxide (K_2O)	0.28
Carbon dioxide (CO_2) (calculated from total Carbon)	0.45
Loss on ignition (minus CO_2 plus loss at 105° C.)	9.03
Total	99.80
Pyrometric cone equivalent (fusion point)	29

Pyrometric cone 29 is equivalent to approximately 3110° F. The company reported through its Technical Director as follows: "Although the material does not fuse until cone 29 is reached, a bloating effect was observed at cone 23 (2894° F.). In our opinion, this would be classified as a buff burning clay. We have been experimenting and have made up several small bricks. Grog (burned clay) of the same material was used as an aggregate in various mesh. Due to the high plasticity of this clay experiments are undei way in an attempt to develop a light weight refractory."

Dr. G. W. Carver,[36] of Tuskegee Normal and Industrial Institute, Tuskegee Institute, Alabama, examined a sample of the black clay, and reported that it was a very good type china clay, firing at a high temperature into a perfectly white mass.

Mellen[37] found 3.0 to 4.0 feet of ball clay, lignitic, tough, tenacious, highly plastic, about 15 feet below the bentonite bed on the Pine Dimension Company property (Sec. 14, T. 12 S., R. 17 W.). Two facies were noted, an upper medium-gray, probably nearly white weathered, and a lower very dark brownish-gray, nearly black. He notes that the clay has a high fusion point, and might be suitable for the manufacture of No. 1 quality fire-brick, and that probably it would burn cream or buff. It could be beneficiated, he says, by blunging and screening or allowing to settle, inasmuch as the iron is commonly in the form of pyrite. He adds that possibly the clay would make a good bond for molding sands; or, the fineness of grain might make it useful as a filler, especially for rubber.

WATER

Normally, Monroe County is well provided with water,[4] although at times of drought certain parts of the county may find the water supply somewhat difficult of access. The water has adequate reservoirs, both Tuscaloosa and Eutaw formations being excellent aquifers, and the river terraces abundantly water-bearing. The Selma formation, although it contains plenty of water, is so compact and clayey in most places that it does not yield water readily, and so is commonly considered non water-bearing. Its chief value as concerns the water supply lies in its service as an impervious cover for the Tuscaloosa and Eutaw aquifers, by which as artesian system has been created. The Tuscaloosa and Eutaw sand and gravel beds, full of water, dip west around 30 feet to the mile, and west of Tombigbee River are covered by the compact Selma Chalk; these geological conditions are ideal for artesian wells. The intake areas of the aquifers are at an elevation sufficient to give a good head to the water in deep wells located in the lowlands along the Tombigbee, at Bigbee, for example, and formerly at Aberdeen and Amory, and in wells west of the river bored through the chalk to the Eutaw or the Tuscaloosa. In wells on the Tombigbee flats or the low terraces along the river, the original pressure was sufficient to force the water to the surface; but wells at slightly greater elevations did not flow. In all cases, however, the artesian pressure was sufficient to raise the water to within easy reach of suction or force pumps. The pressure from the Tuscaloosa beds is stronger than that from the Eutaw. The principal towns of the county—Aberdeen, Amory, Hamilton, Gattman, Smithville—obtain their water supply from artesian wells, and several country communities also are served by the same means. A yield of as much as 200 gallons a minute has been reported from a single well.[4] Many of the flowing wells of some years back have ceased to flow because of the lowering of pressure resulting from the escape of enormous quantities of water through an ever increasing number of wells which in most cases are allowed to flow freely.

The artesian wells range in depth from 120 feet at Smithville in the northern part of the county and Hamilton in the southern part, to 623 feet at Gattman on the eastern border and 620 feet at Muldon in the southwest corner. The well at Gattman is the deepest water well; it obtains water from Pottsville sandstone; the other artesian wells draw their supply from the Tuscaloosa or the Eutaw.[4]

Through the country districts where artesian water is not readily accessible, water for domestic use is drawn from shallow wells and from springs. Springs flowing from the sands and gravel of the Tuscaloosa and Eutaw formations or from the terrace beds are numerous in the eastern and central parts of the county. The shallow wells may be as little as ten feet deep or as much as one hundred, the deeper ones being in the lime region. Much of the water is highly mineralized; Greenwood Springs is a good example. Iron and sulphur compounds are commoner in the eastern part of the county, lime in the western. In the Selma chalk area some cisterns and pools are still in use for water supply.

The mineral matter in solution in the water from certain artesian wells scattered widely over the county is indicated by the table below:

Mineral analyses of ground waters from Monroe County[4]

(Parts per million.)

Wells	1	6	7	12	13	19	20	24
Silica (SiO_2)	16.0	14.0	11.0	13.0	22.0	23.0	14.0	29.0
Iron (Fe)	6.6	20.0	1.0	2.8	1.9	0.15	0.48	1.6
Calcium (Ca)	11.0	5.6	3.9	8.9	18.0	12.0	11.0	24.0
Magnesium (Mg)	3.5	2.5	1.5	3.1	3.8	3.5	2.4	2.5
Sodium potassium (Na-K)	14.0	9.7	6.9	9.8	16.0	85.0	72.0	82.0
Carbonate radicle (CO_3)	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0
Bicarbonate radicle (HCO_3)	77.0	44.0	24.0	57.0	93.0	140.0	171.0	167.0
Sulphate radicle (SO_4)	3.5	6.2	5.2	6.1	5.8	5.9	4.1	4.2
Chloride radicle (Cl)	3.1	1.9	5.5	7.0	4.8	76.0	40.0	80.0
Nitrate radicle (NO_3)	0.38	Trace	0.35	0.0	0.25	0.65	0.35	0.00
Total dissolved solids at 180° C	90.0	60.0	50.0	76.0	122.0	286.0	227.0	314.0
Total hardness as $CaCO_3$ (calcul'td)	42.0	24.0	16.0	35.0	61.0	44.0	37.0	70.0

Location of Wells:

1. Aberdeen, corner of Maple and Commerce Streets
6. Amory, at waterworks, Chestnut and Front Streets
7. Amory
12. Near Acker, 7 miles south of Amory
13. Near Nettleton, 10 miles northwest of Amory
19. Muldon, 200 yards southwest of Gulf, Mobile, & Ohio Railroad Station
20. Muldon
24. Prairie

SOILS

The soil is the most valuable mineral resource of Monroe County, as of all other agricultural regions. And inasmuch as the mineral content of any soil is derived from weathered rock material, which may have been in the place where the soil now is, or may have been transported from elsewhere commonly not far distant, it is expected, logically, that the soil of any region will reflect the character of the rock in that region. In general this relationship among the bed rock, mantle rock, subsoil, and soil exists. In Monroe County, then, the soils of the eastern and central districts are predominantly light and sandy, but in most places have a variable admixture of clay and silt; the subsoils are sandy also, but contain more clay; the mantle rock beneath the subsoil may be predominantly sandy or predominantly clayey, according as the country rock in any particular place may be clay or sand, or dominantly one or the other. In the western part of the county, where the soils are chiefly residual, derived from the Selma impure limestone or chalk similar to that which underlies the region, they are chiefly clay loam to clay, and contain some lime.

The U. S. Department of Agriculture report[2] on its soil survey of Monroe County lists 22 soil types, of which three comprise more than 41 percent of the area. The most extensive, the Orangeburg fine sandy loam, covers approximately 93,000 acres, about 19 percent of the county. In general it is the soil of the hilly region between the valleys of Tombigbee and Buttahatchie Rivers; but a few small patches lie on the hills east of the Buttahatchie. Mechanical analyses of this soil type gave results tabulated in percentages as follows:

Soil: Fine gravel, 0.4 percent; coarse sand, 3.6 percent; medium sand, 4.2 percent; fine sand, 52.2 percent; very fine sand, 8.7 percent; silt, 24.4 percent; clay, 6.1 percent.

Subsoil: Fine gravel, 0.1 percent; coarse sand, 2.1 percent; medium sand, 3.3 percent; fine sand, 37.1 percent; very fine sand, 6.4 percent; silt, 17.7 percent; clay, 33.4 percent.

It will be seen at a glance that the Orangeburg fine sandy loam soil consists of some 69 percent sand, 24 percent silt, and only 6 percent clay. The subsoil runs 49 percent sand and fine gravel, 17.7 percent silt, and 33.4 percent clay. The higher clay content of the subsoil is due to the carrying of the clay particles of the soil downwards into the subsoil by descending water. The Orangeburg soil is a gray sandy loam which ranges in thickness from 8 to 14 inches; the subsoil is a red to brownish-red sandy clay 22 to 28 inches thick. Both soil and subsoil are of types which would normally develop from a formation of the character of the Lower Eutaw.

The Houston clay, the second in area of the three leading soil types, covers 58,176 acres, 12.0 percent of the total area, all west of Tombigbee River. It is dark gray to black, giving rise to the names "black lands" and "black prairie." The subsoil has about the same texture, but is lighter of color, more plastic, and more tenacious, because of higher moisture content and lower content of organic matter. Thickness of soil and subsoil may be as great as 3 feet. The records of mechanical analyses of Houston clay are given below:

Soil: Fine gravel, 0.1 percent; coarse sand, 0.7 percent; medium sand, 0.9 percent; fine sand, 5.6 percent; very fine sand, 14.1 percent; silt, 56.9 percent; clay, 21.6 percent.

Subsoil: Fine gravel, 0.0 percent; coarse sand, 1.2 percent; medium sand, 0.9 percent; fine sand, 7.7 percent; very fine sand, 11.9 percent; silt, 50.4 percent; clay, 28.1 percent.

The Houston clay is said to be the strongest upland soil of the area. Its natural productiveness is phenomenal: in some cases cotton has been grown continuously for 25 years on the same piece of ground, maintaining a yield of 1/2-bale to the acre without the addition of any type of fertilizer.

The Cahaba silt loam, the third of the three leading soil types, has an area of 49,644 acres, or 10.2 percent of the county. It may be called the terrace soil, all except a few patches occupying the terraced belt east of Tombigbee River and immediately west of the area of the Orangeburg fine sandy loam. The soil is a gray silt loam averaging 8 inches thick; the subsoil is a yellowish clay loam to an average depth of 18 inches, where it grades into a yellowish sandy clay. The mechanical analysis record follows:

Soil: Fine gravel, 0.2 percent; coarse sand, 0.8 percent; medium sand, 2.2 percent; fine sand, 13.9 percent; very fine sand, 5.4 percent; silt, 67.0 percent; clay, 10.6 percent.

Subsoil: Fine gravel, 0.3 percent; coarse sand, 0.4 percent; medium sand, 2.4 percent; fine sand, 16.0 percent; very fine sand, 9.8 percent; silt, 49.8 percent; clay, 20.9 percent.

The nineteen other soil types are various combinations of sand, silt, and clay, classified as loams or clays, with the exception of the Houston chalk, which is only 512 acres in extent. The numerous types arise from the working over to which the materials have been subjected by erosive and weathering agencies due to topographic differences, and to variations in the bed rock materials which contributed to the soils. The chemical composition is chiefly silica, alumina, and ferric oxide, but the western soils commonly contain some lime. Humus is almost invariably present to some extent, but is especially abundant in the black prairie soils.

AGRICULTURAL LIMESTONE

The Selma chalk, the lime formation of Monroe County, occupies almost the whole of the county west of Tombigbee River, but in general runs low in calcium carbonate and high in silica, alumina, and iron, in the forms of sand, clay, and iron sulphide, and also in water. Samples from three localities between Aberdeen and Muldon contained percentages of $CaCO_3$ indicated by the results of analyses quoted below:[37]

Sample	Percent $CaCO_3$
V3a—Sec. 5, T. 15 S., R. 7 E.	56.29
V3b—Sec. 5, T. 15 S., R. 7 E.	51.79
V 4—Sec. 9, T. 15 S., R. 7 E.	58.55
V 5—Sec. 26, T. 15 S., R. 6 E.	50.04

All these samples were from the lower Selma beds, not far above the top of the Eutaw. Obviously the rock they represent contains too little $CaCO_3$ to be suitable for use as agricultural lime. The Agricultural Adjustment Administration requirements call for 90 percent $CaCO_3$, or 1800 pounds per 2000-pound ton of material.

Logan[38] mentions a sample of limestone from an outcrop west of Aberdeen which contained 42.12 percent of CaO or 74.97 percent of $CaCO_3$ but he does not give a specific geographic location, and the stratigraphic position is not fixed any more definitely than "the lowermost horizon of the Selma Chalk."

The Arcola limestone is exceptionably pure, as indicated by the analyses records quoted below:

V 1—Sec. 13, T. 12 S., R. 6 E. 96.58
V 2—NW. Cor. Sec. 27, T. 14 S., R. 6 E. 89.07

Unfortunately, the Arcola is very thin. Stephenson and Monroe state that it has a thickness of "a foot or more," and make the further statement, "In Mississippi the Arcola member apparently consists of only one limestone bed about a foot thick."[5] However, the present survey found several outcrops of the Arcola showing thicknesses of three feet or more; or perhaps it should be said that limestone strata of that thickness were found at the Arcola horizon. If Smith's[5] definition of the Arcola is accepted, all the indurated lime beds at the general stratigraphic position of the Arcola should be included in the Arcola.

Although the Arcola as a source of agricultural lime on a large scale is too thin to supply the requirements of a large area, its purity and the fact that it is near the surface under a considerable territory are factors favoring its use, at least locally. In the northeast corner of Section 10, Township 12 South, Range 6 East, in a road cut near the top of the southwest wall of the valley of Old Town Creek, the Arcola limestone crops out under some 13 feet of overburden. The thickness of the indurated ledge here is close to 5 feet, but the westward dip is steep, 12 feet in 200 yards by one measurement. North of this outcrop the limestone can be followed around the slope of the hill and northwestward along the wall of a tributary valley to the level of the floor of the tributary. The overburden is light for a quarter of a mile at least along this small valley. On the north side of this tributary valley, northeast of the road outcrop, the Arcola limestone shows almost at the top of the hill in a farm road about a mile and a half southwest of Nettleton. South of the main outcrop first mentioned, the limestone beds can be traced along the slopes and across the small valleys of Old Town Creek tributaries around to the top of the wall of the main creek valley (Sec. 13, T. 12 S., R. 6 E.) on U. S. Highway 45 E. At this place the Arcola crops out in the highway cut only some 10 feet below the crest of the ridge, and can be followed by limestone fragments and blocks both east and west of the highway. To the west the overburden is relatively light near the top of the ridge for around 0.5 mile; east of the highway the rock is almost at the surface, but shows for only a hundred yards or so.

Holes along the highway south of the outcrop just mentioned, approximately along the strike of the beds, reached the rock at 19 feet and 11 feet. About a quarter of a mile south of the highway cut the rock outcrop is continuous for 100 yards or more along the east wall of a small valley west of the highway; the thickness is perhaps 3 feet. Still farther south along the strike the rock was reached at 19 or 20 feet. From data provided by holes along the highway the descent of the limestone southward in the area was determined to be 1.5 feet in 425 yards, or slightly more than 6 feet to the mile.

Along Mississippi State Highway 8, six miles west of Aberdeen and a mile and a half east of Gibson, the Arcola limestone shows in a ditch at the intersection of the highway and a north-south road. Its thickness here is not more than a foot and the overburden about 10 to 11 feet. People who live in the vicinity say that this rock bed is encountered in wells all around this road intersection.

Possibly the removal of even a moderately heavy overburden, the transportation of the rock to the processing plant, and the drying and crushing and other processing and handling, which may be necessary, may involve a greater expense than the quantity of calcium carbonate to be obtained would justify, even though the rock be of great purity. The Arcola limestone certainly is sufficiently high in $CaCO_3$, but economic factors may interfere with its general use as a source of agricultural lime.

WOOLROCK AND SUB-WOOLROCK

Rock wool, widely used for insulation, is manufactured from impure limestone, which, in addition to lime, contains alumina, silica, magnesia, and ferric oxide, as indicated in the composite analysis record below:[39]

Average analyses from 22 samples of bedrock deposits from which rock wool was produced experimentally.

	Percent
$Si0_2$	31.73
Ignition loss	27.28
CaO	26.96
MgO	7.89
Al_2O_3	5.79
Fe_2O_3	2.21
Total	101.86

It has been found that the carbon dioxide (CO_2) content of a rock is a good index to the value of the rock for the manufacture of rock wool. Any rock having a carbon dioxide (CO_2) content between 20 percent and 30 percent is considered possible raw material for rock wool.[40] Four samples from the southwestern part of Monroe County[37] showed CO_2 percentages between these limits. Two samples from a cut for the Prairie road about 3 miles southwest of Aberdeen and 240 yards west of the Aberdeen branch of the Gulf, Mobile, & Ohio Railroad, showed 56.29 percent and 51.79 percent $CaCO_3$ respectively, which mean 24.77 percent and 22.79 percent CO_2. A sample from a Highway 25 cut 0.5 mile farther south analyzed 58.55 percent $CaCO_3$ or 25.76 percent CO_2. A sample from the bank of a creek 1.5 miles northeast of Muldon, on Highway 25 and the Gulf, Mobile, & Ohio Railroad, showed 50.04 percent $CaCO_3$ and thus 22.02 percent CO_2. It appears from these figures, then, that the CO_2 content of the samples is not far from that which is desirable for rock wool material.

A complete chemical analysis of two samples by the present survey, indicating the relative percentages of the compounds which commonly are present in rock wool material, is recorded below:

Sample	Ign. loss	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	MnO_2	Alkalies Na_2O,K_2O	SO_3	Total	CO_2
P90 (1-2)	22.95	32.17	12.32	3.70	0.55	26.49	0.13	0.04	0.61	0.53	99.49	15.38
P99 (1-2)	29.37	22.00	9.47	2.60	0.44	34.51	0.14	Trace	0.89	0.31	99.73	23.23

B. F. Mandlebaum, analyst.

A considerable number of test-holes were drilled in the Selma outcrop area, but most of them were not sufficiently deep to penetrate rock unaffected by weathering, and as a consequence most of the samples taken were of more or less leached material. It is hardly to be wondered at, then, that analyses of these samples by the survey laboratory showed in most cases low CO_2 and $CaCO_3$; in fact, five of the samples contained neither CO_2 nor $CaCO_3$, and six others ranged from 0.72 percent to 15.38 percent of CO_2. Only samples from Test hole P99 showed more than 20 percent CO_2—these ran 23.23 percent of CO_2 and 52.85 percent of $CaCO_3$. Samples from Test hole P88 contained 19.25 percent of CO_2 and 43.78 percent of $CaCO_3$. In general the lime farther west in the county runs higher in CO_2 and the writer holds the view that large numbers of samples of fresh rock from the western and southwestern parts of the county would show a CO_2 content which would satisfactorily meet wool-rock specifications. The percentage figures given above suggest that enormous quantities of the limy material west of the river in Monroe County possibly are suitable for the manufacture of rock wool. The possibilities should be thoroughly investigated. Conditions for the development of any large deposit in this region are favorable: railroads and highways near, overburden relatively light, water-level low, topography rolling, relief slight, water supply adequate

CEMENT MATERIALS

Portland cement is a hydraulic cement manufactured from raw materials which must contain calcium carbonate, silica, alumina, and iron oxide in proportions which may vary, but only within narrow limits.[24] The raw materials are ground finely, mixed together, and roasted at 3000° F. or over, to incipient fusion. The mixture should consist approximately of three parts $CaCO_3$ or an equivalent percentage of CaO, to one part of SiO^2, Al_2O_3 and Fe_2O_3. The ratio of lime (CaO) in the cement to the silica, alumina, and iron oxide together should not be less than 1.6 to 1, or more than 2.3 to 1.[41] The product of the roasting, "cement clinker," is pulverized, sacked, and sold as the Portland cement of commerce.[24] Crider states that a study of 81 analyses of American brands of Portland cement showed that the lime oxide content ranged from 58.07 to 65.44 percent; silica from 19 to 24 percent; alumina and iron oxide together from 6.0 to 13.5 percent; magnesia from a trace to 3.5 percent; alkalies up to 2.25 percent, and sulphur trioxide from a fraction of 1 percent to 2.786 percent. He gives the average as CaO, 62 percent; SiO_2, 21.75 percent; Al_2O_3 and Fe_2O_3 together, 10.5 percent.[41]

Portland cement has the property of setting, in drying from a wet state, to a hard rock. Mixed with gravel or sand or other more or less coarsely divided mineral substance, it forms concrete. Portland cement and concrete are perhaps the most widely used of all mineral building materials, with the possible exception of brick.

Commonly limestone and shale or clay are used as raw materials, and if the limestone contains sufficient clay to provide the necessary silica and alumina, clay from a separate formation may not have to be added. In all cases Portland cement plants are located where the raw materials are abundant—near large deposits of both limestone and shale or clay.

Monroe County includes a large wedge of the Selma chalk terrane, which, as has been stated, is composed of lime, sand, clay, and silt mixed in almost every conceivable manner and proportion; but insofar as has been ascertained up to the present, no part of the chalk formation of the county is sufficiently high in lime to be suitable for the manufacture of Portland cement, unless it is the Arcola limestone member, which is too thin to be of importance for this purpose.

The Demopolis, Alabama, cement plant used Selma chalk as a source of lime, and residual clay from the Selma as a source of silica, alumina, and iron oxide. Analyses of the chalk used by the Demopolis plant are given by Crider:[43]

Analyses of Selma limestone used at the Alabama Portland cement plant, Demopolis, Alabama.

	1 Percent	2 Percent
Silica (SiO_2)	12.50	9.88
Alumina (Al_2O_3) and iron oxide (Fe_2O_3)	2.76	6.20
Lime carbonate ($CaCO_3$)	80.71	77.12
Magnesium oxide (MgO)	1.05	1.08
Sulphur trioxide (SO_3)	1.62	n.d.
Water	1.36	5.72

A comparison of these figures with those of the $CaCO_3$ content of samples of chalk from western Monroe County, as given in the discussion of agricultural limestone—56.29, 51.79, 58.55, 50.04—makes evident the deficiency of the Monroe County material for use in the manufacture of Portland cement. It is possible, however, that the Selma chalk of Monroe County might be suitable for making natural cements, which do not require so high a percentage of lime, and allow of more latitude in the lime-silica-alumina-iron ratio.[41]

BUILDING ROCK

The formations of Monroe County do not contain any rock suitable for general use in building. Ferruginous sandstone is common in the Lower Eutaw, but is scattered throughout the formation. Thin, much restricted layers break into platy fragments when the containing beds crumble, and large masses, of very irregular shape, are conspicuous in many localities, especially in the uppermost parts of the highest ridges. In fact, most of these elevations owe their very considerable height to the resistance to weathering offered by masses of hard sandstone which compose their upper parts. Of the number of places where notable thicknesses of this sandstone have been developed, one of the best is on the Bentley property (About midde N. 1/2, Sec. 18, T. 14 S., R. 16 W.); here huge masses project from the summit and upper slopes of one of the highest elevations of the county. Many tons of it have been dug out for use in the building of foundations and chimneys or for stopping of erosion or for various other farm purposes. In eastern Monroe County, as in many other parts of the state, perhaps the most widespread uses to which this type of sandstone has been put are in the construction of chimneys, and as foundation blocks for farm houses. Also, in many parts of the state, it has been crushed for use on the roads; if broken into sufficiently small pieces, it is excellent road metal. However, it is used little if at all for this purpose in Monroe County, because of the abundance of gravel.

The writer believes that more general use should be made of this sandstone for building purposes, at least locally. If chimneys can be built of it, so can houses and outbuildings. Of course obstacles would have to be overcome. A first consideration is, that the rock is almost invariably in places which are difficult of access, and so would be expensive to transport; in some cases roads would have to be built before quarries could be opened. A second consideration is, that the rock is so very irregular of form and varies so greatly in degree of cementation that quarrying and proper shaping of blocks for building would be difficult. To people who never indulge in long-term planning, the obstacles mentioned above, and others they could readily think of, specifically the labor involved, would be insuperable; but to people who think in terms of tomorrow and the day after as well as of today, the obstacles might be outweighed by certain advantages to be gained by the utilization of the rock in spite of obstacles. A primary consideration on this side is that the structures built of this material are permanent, so far as the reckoning of time by the span of a human life is concerned: they are proof against fire, against storms, and against the more quiet weathering processes; against termites and all other insects, and even to a degree against earthquakes. Perhaps if a building of this kind of rock were located where it could be reached by floods, it might be undermined. And it isn't protection against a mortgage. But, as can readily be seen, although the initial cost would be much greater than the cost of a frame building would be, the upkeep would be little if anything, and the rock structure would be standing firm and in as good condition as when it was built, after many frame buildings had come and gone. And another consideration, secondary perhaps to people of a "practical" turn of mind, is that a building constructed of this rock harmonizes well with the landscape, and contributes to the attractiveness of the country rather than detracts from it as do so many of the disreputable looking wooden structures now standing. Excellent examples of what can be done with native ferruginous sandstone, or iron sand rock, as it is commonly called, as structural material, are the main building, walks, stairways, fences, and some other structures at Lake Choctaw, near Ackerman, Choctaw County. Many handsome dwellings in and near Meridian, Mississippi, also, are built of this kind of native rock. Rock of the kind used at Lake Choctaw and at Meridian is abundant in eastern Monroe County.

The conglomerate which shows prominently in the gravel beds in many places could be used as building material also, although it is very difficult to work. It, too, has been used to some extent in chimneys, foundations, and well-curbs.

The Arcola limestone, particularly one stratum, in the localities where seen is sufficiently indurated for use as building stone; indeed it is so tenacious that it is very difficult to break with a hammer. However, it probably would not do for outdoor work, because it would break down too easily under the weather. Similar rock has been used for fireplaces except for the part subject to the greatest heat, and for mantels, but can not be especially recommended for such uses.

Some strata in the Tombigbee sand are strongly indurated, but probably would not stand up in a building.

None of the indurated beds in Monroe County is of wide extent except the Arcola limestone. The ferruginous sandstones of the lower Eutaw are irregular discontinuous strata or masses which may be at almost any level.

MISCELLANEOUS MINERALS

Very small quantities of a few other mineral substances exist in the Monroe County formations. None has been found in sufficient quantity to be of commercial importance. Iron ore is represented by scattered limonite and siderite and by marcasite concretions. Limonite is in the form of concretions, crusts or laminae or irregular accumulations in the beds, and siderite chiefly in the form of concretions of a great variey of shapes. Commonly the siderite concretions are included in the blue clays and sands and the lignites of the Tuscaloosa.

The glauconitic sand of the Tombigbee member of the Eutaw contains small percentages of potash, but analyses have shown not more than 1 percent. Similar sand in the eastern part of the United States, found to contain several percent of potash, has been used as a soil fertilizer.

Phosphatic nodules from the Eutaw-Selma contact and from a little above the Arcola limestone have been mentioned. No chemical analysis of these is available, but several samples of so-called phosphate rock from the western part of the county were collected by the late C. L. Tubb and submitted for analysis. Four of these were from Section 29, Township 12 South, Range 7 East. None showed more than 1 percent lime phosphate.

Samples collected from time to time from different parts of the county have been analyzed for manganese, but none showing a percentage greater than 1 percent to 2 percent has been found.

Lignite crops out in several places in the eastern part of the county, and was encountered in a number of holes, but no thickness greater than 3 feet was found. Needless to say, the quantity is too small to be of consequence, even if the quality were good, which it is not, and geographical and economic conditions were such that lignite could be used, which they are not. Brown[42] mentions a report of a 3-foot bed of lignite on the Dean place, 1.5 miles from Greenwood Springs. Test-hole P-53 of the present survey, on the Dean property, penetrated three beds of black clay and sand, of thicknesses 1.2, 3.4, and 4.0 feet respectively, but no lignite. As stated above, however, lignite was found in several holes elsewhere. Commonly it contained much iron sulphide and lignitized wood.

Some few pieces of amber (fossil resin) have been found in the county, in association with beds of lignite or lignitic clay. Mr. I. Faulkner gave the writer a few pieces which he found in a creek back of his house (Sec. 35, T. 12 S., R. 17 W.). This material has not been found in sufficient quantity to be of value.

Bauxite was reported from a place or two, but investigation failed to find it.

It may be pertinent to mention here also that analyses of natural gas from the Amory gas field showed 0.12 percent and 0.16 percent of helium.[13f]

TEST HOLE RECORDS

JOHN ADDINGTON PROPERTY

TEST HOLE P1

Location: T. 12 S., R. 16 W., Sec. 9, NE. 1/4; east side of Oak Hill school and Detroit road, some 2 miles southeast of Oak Hill school, 200 yds. northwest of the Addington home Drilled: August 13, 14, 1941

Elevation: 425 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.6	0.6	Soil; sandy clay, reddish yellow
2	2.0	1.4	Sand, clayey, brown
			Tuscaloosa formation
3	5.0	3.0	Clay, light-gray; with brown streaks and spots; very sandy
4	8.0	3.0	Clay, dark blue-gray waxy; contains fine sand.
5	10.0	2.0	Clay, light-gray slightly sandy; some golden yellow streaks.
6	11.0	1.0	Clay, blue-gray; some rust spots; contains sand
7	15.3	4.3	Clay or silt, yellow sandy; Sample 1
8	17.6	2.3	Clay, dark blue-gray slate color; streaks of rusty brown; silty
9	23.6	6.0	Clay, light-gray; contains some very fine sand
10	24.6	1.0	Clay, light blue-gray; with some rust spots; contains fine sand; Sample 2

Will Brown Property

Test Hole P2

Location: T. 12 S., R. 16 W., Sec. 5; SE. corner, 50 ft. east of road which leads southeast from Oak Hill school on Smithville-Pikeville road; about 1 mile southeast of the school building. Drilled: August 12, 13, 1941

Elevation: 437 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.3	0.3	Soil, gray and black fine sandy loam
			Eutaw formation
2	2.3	2.0	Sand rock, brown; brownish-gray sand
3	5.0	2.7	Clay, very sandy red-brown
			Tuscaloosa formation
4	5.7	0.7	Clay, light-gray sandy
5	7.3	1.6	Clay, dark-blue to dark-gray
6	10.9	3.6	Clay, light-gray
7	13.5	2.6	Clay, dark-blue to dark-gray; contains fine sand
8	19.0	5.5	Clay, light bluish-gray; with yellow iron rust Sample 1
9	28.3	9.3	Clay, dark blue-gray to light-gray sandy; Sample 2
10	31.1	2.8	Clay, gray sandy; Sample 3
11	33.2	2.1	Clay, light-gray and some black sandy; Sample 4
12	41.4	8.2	Clay, dark-gray to nearly black sandy

L. O. Commander Property

Test Hole P7

Location: T. 12 S., R. 16 W., Sec. 5, NW 1/4; 5 ft. west of Hamilton and Smithville road, 300 yds. N. of Oak Hill School, under pine tree
Drilled: Dec. 4, 5, 6, 1941

Elevation: 460 ft. Water level: 28.5 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil
			Eutaw formation
2	4.4	3.9	Clay, light-gray; with abundant fine sand; micaceous; slightly rusty
			Tuscaloosa formation
3	9.0	4.6	Clay, gray slightly brown-tinted; contains golden rust streaks and fine sand
4	15.8	6.8	Clay, light-gray shaly; golden rust streaks; contains fine sand; Sample 1
5	16.8	1.0	Clay, gray shaly; contains fine sand
6	21.7	4.9	Clay; very little sand; dark gray, laminated, silty, slightly micaceous; Sample 2
7	33.2	11.5	Sand, very fine; with little clay; gray, somewhat lighter than above, slightly micaceous; Sample 3
8	38.5	5.3	Clay, dark-gray; with yellow sand; Sample 4
9	40.0	1.5	Sand and rock, yellow

E. H. Addington Property

Test Hole P12

Location: T. 12 S., R. 16 W., Sec. 6, N. 1/2, SW. 1/4. Lots 12 and 13; north of Smithville and Pikeville road 10 yards in front of the Addington home, some 300 yards east of Splunge Creek Drilled: August 11, 1941

Elevation: 370 ft. Water level: 14 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.8	0.8	Soil
			Tuscaloosa formation
2	4.5	3.7	Sand, silty or clayey light-gray; brown stained; thin yellow layer at bottom; laminated; Sample 1
3	8.0	3.5	Clay or silt light-gray; very little fine sand; Sample 2
4	14.0	6.0	Clay, light-gray; with crusts of rusty yellow sand; thin sand rock; Sample 3
5	15.0	1.0	Sand, yellow
6	19.4	4.4	Sand, blue

B. H. Coker Property

Test Hole P15

Location: T. 12 S., R. 10 E., Sec. 8, NW. 1/4; west of the B. H. Coker home 250 yards, and 12 feet north of the Smithville-Pikeville road
Drilled: August 20, 21, 1941

Elevation: 432 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Eutaw formation
1	3.2	3.2	Clayey sand, brown and gray
2	4.7	1.5	Clayey sand and rocks, gray
3	5.2	0.5	Clay, light-gray shaly; contains fine sand
4	6.0	0.8	Sand, brown and gray clayey or silty very fine
5	7.1	1.1	Sand, light-gray and rust-brown fine
6	9.3	2.2	Sand and thin sand-rock, rust-brown; sand fine to medium
7	13.4	4.1	Sand rock, dark-brown; and brown sand, fine to medium
			Tuscaloosa formation
8	14.3	0.9	Clay, bluish-gray slightly micaceous; contains fine sand
9	19.8	5.5	Clay, dark-gray somewhat sandy; Sample 1
10	23.3	3.5	Clayey sand or sandy clay, shaly light-bluish-gray; Sample 2
11	30.5	7.2	Clayey sand or sandy clay, shaly; darker gray than preceding interval; Sample 3
12	41.0	10.5	Clay, blue; no grit; turns green on exposure; montmorillonitic?

F. M. Johnson Property

Test Hole P17

Location: T. 12 S., R. 9 E., Sec. 2, NE. 1/4; 12 yards north of Smithville and Pikeville road and west of Johnson home 300 yards Drilled: August 5, 1941

Elevation: 393 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, brown sandy loam
2	1.5	1.0	Clay, brown sandy
			Tuscaloosa formation
3	7.0	5.5	Clay, gray very sandy pink spotted
4	10.4	3.4	Clay, gray rusty and brown very sandy
5	25.0	14.6	Clay, blue; with some yellow and white sand; Sample 1
6	26.0	1.0	Sand, yellow micaceous

J. F. Sallis Property

Test Hole P26

Location: T. 12 S., R. 16 W., Sec. 7, N. 1/2, NE. 1/4; about 200 yards south of the J. F. Sallis residence, 15 yds. west of road and ± 0.7 mile south of Bethlehem Church Drilled: August 15, 1941

Elevation: 450 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent and Eutaw formations
1	6.5	6.5	Sand, silty light-gray flaky somewhat rusty
2	14.0	7.5	Silt or clay, sandy laminated light-gray micaceous
			Tuscaloosa formation
3	15.5	1.5	Silt or clay, light blue-gray laminated; contains fine sand; Sample 1
4	21.0	5.5	Clay, blue-gray to light-gray sandy; Sample 2
5	26.5	5.5	Clayey sand, grayish slate; more sand than clay; micaceous; Sample 3

J. D. Ray Property

Test Hole P30

Location: T. 12 S., R. 16 W., Sec. 28, SW. 1/4; on east side of Scott Settlement Road a little north of the junction of this road with road west to old water mill on Sipsey River Drilled: Nov. 6, 7, 1941

Elevation: 400 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Surface soil; sandy loam
2	1.5	1.0	Sand and clay, red-brown
			Tuscaloosa formation
3	9.0	7.5	Clay, light-gray; some yellow streaks; sandy; Sample 1
4	13.0	4.0	Clay, yellow very hard and fine sandy; Sample 2
5	14.0	1.0	Sand, light yellowish-gray and white very fine micaceous
6	18.5	4.5	Sand, gray and yellow

TOBE SIMMS PROPERTY

TEST HOLE P32

Location: T. 12 S., R. 17 W., Sec. 25, SE. 1/4; 0.7 mile northwest of intersection of Splunge and Greenwood Springs road with Amory-Detroit road, 20 feet north of center of Detroit Road under a crooked pine tree
Drilled: Oct. 28, 29, 1941

Elevation: 395 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	2.0	2.0	Soil
			Tuscaloosa formation
2	3.5	1.5	Clay, light-gray rust-mottled very sandy; more a clayey fine sand than a clay
3	6.0	2.5	Clay, light bluish-gray; contains fine sand; Sample 1
4	7.0	1.0	Sand rock, yellow
5	11.0	4.0	Sand, fine gray and rust-yellow micaceous
6	12.0	1.0	Sand rock, brown
7	14.5	2.5	Clay, dark-gray shaly a little rusty; contains much fine sand; Sample 2
8	22.0	7.5	Clay, shaly dark-gray somewhat micaceous; contains much fine sand; Sample 3
9	25.0	3.0	Sand, yellow and gray clayey
10	44.0	19.0	Sand, light-gray to dull white fine

B. B. GILLILAND PROPERTY

TEST HOLE P35

Location: T. 12 S., R. 17 W., Sec. 24, western part; in west wall of valley of Splunge creek, on S. side of road 1/4 mile W. of house at foot of slope
Drilled: Sept. 26, 29, 1941

Elevation: 415 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil
			Eutaw formation
2	1.7	1.2	Sand, light brownish very fine
3	7.6	5.9	Sand, red-brown fine; contains small pieces of sand rock
4	11.8	4.2	Sand, very fine clayey light bluish-gray somewhat rusty; Sample 1
5	14.1	2.3	Sand, fine rust-brown and a little dull white slightly micaceous
			Tuscaloosa formation
6	15.1	1.0	Clay, lignitic black sandy
7	20.8	5.7	Clay, dark-gray somewhat rusty; growing darker downwards; Sample 2
8	26.4	5.6	Clay, dark-blue; a little fine sand; Sample 3
9	34.7	8.3	Clay, dark-gray to almost black; a little fine sand; Sample 4
10	37.3	2.6	Clay, light-gray; black streaks
11	40.0	2.7	Lignite, black

MRS. COOPER JONES PROPERTY

TEST HOLE P36

Location: T. 12 S., R. 17 W., Sec. 24, NW. 1/4; about 100 yds. west of Splunge-Bethlehem church road, on slope, some 20 to 25 feet above base of slope
Drilled: Dec. 16, 1941

Elevation: 412 ft. Water level: 6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Sandy soil
			Eutaw formation
2	4.5	4.1	Sand, brown
3	6.0	1.5	Sand, brown; bentonite and rocks
4	11.5	5.5	Bentonite, (Water); Sample 1
5	17.0	5.5	Sandy clay, gray and brown
			Tuscaloosa formation
6	21.0	4.0	Sand and clay, blue
7	22.5	1.5	Sand and clay, gray
8	24.8	2.3	Sand rock and gravel, yellow (Rock)

MRS. COOPER JONES PROPERTY

TEST HOLE P37

Location: T. 12 S., R. 17 W., Sec. 24, NW. 1/4; 100 yards north of road leading out Gilliland Place, intersecting Detroit and Amory Road
Drilled: Dec. 17, 1941

Elevation: 400 ft. Water level: 6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.6	0.6	Soil
			Eutaw formation
2	6.0	5.4	Sand, brown
3	13.0	7.0	Bentonite; mixed with brown clay and sand (Water); Sample 6
4	15.0	2.0	Sand, brown
			Tuscaloosa formation
5	16.0	1.0	Clay, black

I. C. Faulkner Property

Test Hole P39

Location: T. 12 S., R. 17 W., Sec. 35, near center; 20 ft. from road on west side under hickory tree; 1/4 mile west of the Faulkner mill
Drilled: Nov. 17, 1941

Elevation: 390 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil
			Eutaw formation
2	7.4	6.9	Sand, red-brown clayey
			Tuscaloosa formation
3	10.0	2.6	Clay, gray rusty
4	12.5	2.5	Clay, black to dark-gray; contains fine sand or silt
5	14.5	2.0	Clay, light-gray slightly silty
6	20.0	5.5	Clay, black and gray lignitic; Sample 1
7	21.0	1.0	Clay, light-gray
8	22.8	1.8	Clay, lignitic dark blue to black
9	30.9	8.1	Clay, grayish-blue very sandy; to blue sand; some sand rock; Sample 2
10	40.0	9.1	Sand, blue; little clay

J. A. Lann Property

Test Hole P40

Location: T. 12 S., R. 17 W., Sec. 23, SW. 1/4; 30 ft. south of road and 75-100 yds. northeast of the Lann house Drilled: Oct. 28, 1941

Elevation: 384 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	0.5	0.5	Soil
			Eutaw formation
1	13.0	12.5	Sand, brown and gray very fine silty
			Tuscaloosa formation
2	15.0	2.0	Clay, brown and gray silty; rust-colored sand
3	16.6	1.6	Clay, black lignitic; contains fine sand or silt
4	20.5	3.9	Sand, bluish-gray very fine micaceous
5	24.2	3.7	Clay, dark-gray silty slightly micaceous
6	25.4	1.2	Lignite, black
7	34.6	9.2	Sand, very fine light-gray slightly micaceous
8	41.6	7.0	Sand of all colors

D. W. TATE PROPERTY

TEST HOLE P42

Location: T. 13 S., R. 16 W., Sec. 9, SW. 1/4; 100 ft. north of Sipsey Fork-Sulligent Road and 1/4 mile or less west of Alabama-Mississippi line
Drilled: Nov. 7, 1941

Elevation: 375 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	0.5	0.5	Soil
			Tuscaloosa formation
1	3.8	3.3	Clay, light-blue and little brown; dries light-gray with faint reddish tint; silty
2	4.4	0.6	Clay, dark-brown; contains fine sand; dries brownish gray
3	14.4	10.0	Clay, gray and yellow sandy; light-gray with golden yellow rust; fine sand
4	21.3	6.9	Clay, blue; with sand; dries light-gray; silty; Sample 1
5	23.6	2.3	Clay, black; with sand, dark-gray; silty
6	31.1	7.5	Clay, light-gray; yellow and brown streaks; contains silt or very fine sand; Sample 2

H. C. HAMILTON PROPERTY

TEST HOLE P44

Location: T. 13 S., R. 17 W., Sec. 1, SW. 1/4; on south side of road about 1 mile west of Splunge on hill slope Drilled: Oct. 30, Nov. 5, 1941

Elevation: 390 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.6	0.6	Surface Soil
			Tuscaloosa formation
2	6.3	5.7	Sand; little clay mixed, reddish-brown and light
3	7.0	0.7	Clay, light-gray pure; very little fine sand; Sample 1
4	8.0	1.0	Sand rock, brown
5	8.5	0.5	Sandy shaly rock, red-brown
6	11.5	3.0	Sand and clay, gray and yellow
7	13.0	1.5	Clay, gray; Sample 2
8	20.0	7.0	Clay, sandy gray; Sample 3
9	22.0	2.0	Clay and sand, yellow ochre color
10	23.5	1.5	Sandy shale, rusty brown; lumps of gray clay
11	24.0	0.5	Clay and sand, gray; mixed with rusty brown shale
12	25.5	1.5	Sand, gray and yellow
13	28.5	3.0	Sand, gray

W. C. Abrams Property

Test Hole P46

Location: T. 13 S., R. 17 W., Sec. 12, NW. 1/4; (or Sec. 11, NE. 1/4); under walnut tree 10 yds. northeast of old house, 30 yds. north of road
Drilled: August 27, 28, 1941

Elevation: 380 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	0.5	0.5	Surface soil
			Tuscaloosa formation
1	8.5	8.0	Sand, chiefly clayey and silty; originally gray, but now almost entirely red-brown from iron oxide
2	12.5	4.0	Sand, red-brown fine micaceous; some gray silty lumps
3	17.0	4.5	Sand, dull white and brown silty fine micaceous
4	20.0	3.0	Sand, fine red-brown and gray micaceous lumpy
5	23.0	3.0	Clay, lignitic dark blue-gray and black; contains some fine sand; Sample 1
6	38.0	15.0	Sand, chiefly fine silty or clayey bluish-gray; had a green cast shortly after exposure to air; Sample 2

Lon Guyton Property

Test Hole P47

Location: T. 13 S., R. 16 W., Sec. 17, NE. 1/4; about 3/4 mile east of Scott Settlement road east of Sipsey River Drilled: Dec. 10, 1941

Elevation: 350 ft. ± Water level: 6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.8	0.8	Surface soil
			Eutaw formation
2	6.0	5.2	Sand, fine brown and yellow micaceous; contains small clay particles
			Tuscaloosa formation
3	9.0	3.0	Clay, dull-white to light-gray; rust-spotted
4	10.5	1.5	Clay, yellow ocherous wet; struck solid rock

J. W. RAY PROPERTY

TEST HOLE P50

Location: T. 13 S., R. 16 W., Sec. 30, NW. 1/4; 30 ft. south of Sipsey River-Gattman road, and 75 to 100 yards southwest of the Ray home
Drilled: Oct. 30, Nov. 5, 1941

Elevation: 330 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designation of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, rust-brown sand; contains some small gravel
			Tuscaloosa formation
2	4.5	4.0	Sand, white; clay
3	11.4	6.9	Clay, light-gray to white; contains fine sand; Sample 1
4	16.2	4.8	Sand, gray and yellow
5	22.2	6.0	Clay, gray and yellow; sand of many colors; Sample 2
6	23.8	1.6	Sand, yellow and gray

J. W. RAY PROPERTY

TEST HOLE P50 OC

Location: T. 13 S., R. 16 W., Sec. 30, NW. 1/4; from ditch on south side of Sipsey Creek-Gattman road, in east wall of Sipsey Valley; 50 ft north of Test Hole P50 Dug: Oct. 30, 1941

Elevation: 320 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Tuscaloosa formation
	3	3	Sample of light-gray to dull white sandy clay dug from south bank of road cut from bottom of roadside ditch to height of about 3 feet; 1 large bag

Walter Dean Property

Test Hole P53

Location: T. 13 S., R. 17 W., Sec. 23, NW. 1/4; 200 yards west of the Dean home and 10 ft. north of the road Drilled: Oct. 21, 22, 23, 1941

Elevation: 340 ft. Water level: 15.3 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Soil
			Eutaw formation
2	4.8	4.4	Sand, brown fine; some rocks
			Tuscaloosa formation
3	10.4	5.6	Clay, very sandy gray, rusty
4	11.6	1.2	Clay, dark-gray to black lignitic sandy
5	15.3	3.7	Clay or silt, light-gray very sandy; or clayey sand
6	18.0	2.7	Sand, blue-gray; yellow iron rust
7	20.0	2.0	Clay, light-gray very sandy; fine sand; Sample 1
8	23.4	3.4	Clay, black lignitic sandy; Sample 2
9	27.0	3.6	Clay, light-gray; contains fine sand; Sample 3
10	31.0	4.0	Clay, black to dark-gray very sandy
11	35.4	4.4	Sand, light-gray very fine
12	45.0	9.6	Clay or silt, light-gray sandy

C. H. Cantrell Property

Test Hole P55

Location: T. 13 S., R. 18 W., Sec. 24, NE. 1/4; 1/4 mile north of Highway No. 6 and 325 yards northwest of the Cantrell home Drilled: Sept. 25, 1941

Elevation: 390 feet ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Eutaw formation
1	0.8	0.8	Rock and sand
2	11.6	10.8	Clay, dark-blue; very little sand
3	15.0	3.4	Sand, very fine light-brown to dull white micaceous

Phillips Property

Test Hole P57

Location: T. 14 S., R. 16 W., Sec. 5, eastern part; 1/2 mile due south of Gattman, 40 yds. west of state line road, half way up hillside
Drilled: Sept. 9, 10, 1941

Elevation: 341 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	1.0	1.0	Soil, light-gray sand
			Eutaw formation
1	6.5	5.5	Sand, rusty red-brown fine to medium lumpy
			Tuscaloosa formation
2	7.0	0.5	Clay, light-gray slightly rusty; contains fine sand
3	9.0	2.0	Clay, dark slaty-blue; contains fine sand
4	12.5	3.5	Clay, yellowish-gray sandy; probably laminated in the bed; Sample 1
5	15.5	3.0	Clay, light-gray slightly rusty; contains fine sand
6	16.5	1.0	Clay, gray rusty; contains fine sand
7	25.0	8.5	Sand, fine light-gray rusty clayey; Sample 2
8	31.5	6.5	Clay, gray; rust-mottled with orange and red-brown; sandy; grades into clayey sand downwards; Sample 3
9	32.5	1.0	Sand, orange-yellow rock; medium to fine

T. E. Danner Property

Test Hole P58

Location: T. 14 S., R. 16 W., Sec. 8, NE. 1/4; 75 yards south of the Danner home and 50 yards south of road — Drilled: Sept. 9, 10, 1941

Elevation: 340 ft. — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil
			Eutaw formation
2	2.9	2.4	Sand, light-brown to red-brown very fine; contains fragments of brown sand rock
3	5.0	2.1	Clay and red-brown sand; lumps of light-gray sandy and silty clay in a matrix of red-brown micaceous fine sand
			Tuscaloosa formation
4	6.0	1.0	Clay or silt, shaly light-gray to light-brown; contains fine sand
5	10.0	4.0	Clay, light-gray; contains fine sand lumps in a matrix of iron-brown micaceous fine sand and some fragments of brown sand rock
6	12.5	2.5	Clay and sand; light-gray sandy clay mixed with light-brown fine micaceous sand and some fragments of brown iron sand rock
7	14.1	1.6	Sand, fine red-brown, yellow, and dull-white very micaceous
8	15.4	1.3	Sand, fine micaceous light-brown to dark-brown and dull white lumpy; contains thin fragments of brown sand rock
9	18.0	2.6	Sand, shaly gray and bluish-gray very fine clayey and silty, micaceous
10	20.4	2.4	Clay or clay-shale, slate-gray very sandy; Sample 1
11	24.4	4.0	Sand, lumpy very fine clayey light-gray to dark-gray to nearly black; could be called a very sandy clay or clay-shale
12	26.4	2.0	Clay, light bluish-gray; contains much fine sand; Sample 2
13	32.5	6.1	Clay, very sandy; or fine clayey or silty sand, light-gray to light-brown; Sample 3
14	34.6	2.1	Clay, very sandy light-gray lumpy
15	39.2	4.6	Sand, chiefly silty or clayey blue to bluish-gray or light-gray somewhat micaceous; Sample 4
16	39.5	0.3	Sand, lignite-brown; fragments of iron carbonate, ferruginous sand rock, and marcasite

PROPERTY

TEST HOLE P59

Location: T. 14 S., R. 16 W., Sec. 8, southern part; 12 yds. west of State Line Road, about 2 miles south of Gattman Drilled: Nov. 3, 1941

Elevation: 440 ft. Water level: 20.0 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.3	0.3	Soil
			Eutaw formation
2	6.3	6.0	Sand, red-brown clayey
			Tuscaloosa formation
3	10.5	4.2	Clay, light-gray rusty; Sample 1
4	13.5	3.0	Clay, light blue-gray rusty; Sample 2
5	17.4	3.9	Sand, brownish-gray clayey somewhat rusty
6	18.5	1.1	Clay, brownish-gray; as above but darker; somewhat rusty
7	20.0	1.5	Clay, light brownish-gray rusty; contains very fine sand
8	23.1	3.1	Clay, light-gray; very little sand or silt; Sample 3
9	28.6	5.5	Clay, dark-gray to black

A. C. KELLEY PROPERTY

TEST HOLE P60

Location: T. 13 S., R. 16 W., Sec. 32, SE. 1/4; 60 yds. south of Highway No. 6; south of the Kelley home 100 yds. Drilled: Aug. 6, 7, 8, 1941

Elevation: 343 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Eutaw formation
1	3.5	3.5	Clayey sand, reddish-brown micaceous fine to medium
			Tuscaloosa formation
2	11.4	7.9	Sand, yellowish to light-gray or dull white micaceous clayey or silty very fine
3	12.0	0.6	Sand, grayish; black streaks
4	16.0	4.0	Sand, brown fine micaceous
5	21.0	5.0	Clay, black; some lumps of marcasite; dries dark brownish-gray; Sample 1
6	33.5	12.5	Clay, dove-gray; Sample 2
7	38.2	4.7	Clay, light-gray and red sandy; Sample 3
8	40.0	1.8	Sand rock, yellowish-brown

A. C. Kelley Property

Test Hole P61

Location: T. 14 S., R. 16 W., Sec. 6, NE. 1/4; 75 yards south of Highway No. 6; 1 1/4 miles west of Gattman, Miss.; 10 yards east of house, under apple tree Drilled: Aug. 6, 7, 1941

Elevation: 322 ft. Water level: 20 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.6	0.6	Soil
			Eutaw formation
2	7.0	6.4	Sand, red-brown clayey or silty micaceous; Sample 1
			Tuscaloosa formation
3	7.6	0.6	Sand, clayey or clay, sandy
4	8.1	0.5	Sand, black, mixed with some harder substance
5	13.0	4.9	Clay or silt, gray and yellow mixture; contains much fine sand; Sample 2
6	29.5	16.5	Clay, blue-gray; slight differences in shade of gray; sandy; Sample 3

J. T. Cox Property

Test Hole P63

Location: T. 14 S., R. 17 W., Sec. 1; a little east of the center; northeast of Cox home 200 yds., west of road 15 yds. Drilled: Sept. 11, 12, 15, 1941

Elevation: 335 ft. Water level: 41.5 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.3	0.3	Soil
2	2.0	1.7	Sand, clayey red-brown micaceous (subsoil)
			Tuscaloosa formation
3	5.0	3.0	Sand, clayey; or clay, sandy, gray and brown, rusty
4	9.0	4.0	Clay, sandy light-gray to dark bluish-gray and yellow
5	15.0	6.0	Clay, sandy dark bluish-gray brown and yellow; Sample 1
6	20.4	5.4	Clay, sandy lignite-brown
7	40.0	19.6	Clay, blue to black or very dark gray sandy; Sample 2
8	41.5	1.5	Clay and sand, blue to black; wet and sticky
9	42.5	1.0	Sandrock, brown; mud, water
10	47.3	4.8	Clay, black or blue; and some sand; wet
11	48.0	0.7	Sand, blue

Charles Hollis Property

Test Hole P66

Location: T. 14 S., R. 17 W., Sec. 12, NW. 1/4; 10 ft. east of cut-off road east of Wolfe Road, 40 yards northeast of tenant house Drilled: Sept. 17, 22, 1941

Elevation: 340 ft. Water level: 32.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, light-brown to light-gray sandy loam
			Tuscaloosa formation
2	2.5	2.0	Sand, light-brown to light-gray very fine silty
3	3.1	0.6	Sand, clayey and silty light-gray and rust-brown
4	6.0	2.9	Clay, sandy light-gray and rusty brown, lumpy
5	8.4	2.4	Clay, light-gray to dark bluish-gray to black; contains a little fine sand; Sample 1
6	9.0	0.6	Sand, fine light-gray to pinkish-gray somewhat clayey
7	13.0	4.0	Clay, light-gray to black; somewhat rusty; contains a little fine sand; Sample 2
8	17.4	4.4	Clay, dark-gray to black, rust-spotted; Sample 3
9	18.5	1.1	Clay, sandy gray and rust-yellow
10	20.9	2.4	Clay, lignitic dark-brown sandy
11	24.0	3.1	Sand, clayey light-gray
12	28.0	4.0	Sand, light bluish-gray very fine
13	32.6	4.6	Sand, light-gray and yellow micaceous; a little sand rock
14	36.0	3.4	Sand and clay, blue. Water and mud
15	38.2	2.2	Clay and sand, blue. Water and mud

W. G. Wise Est. Property

Test Hole P67

Location: T. 14 S., R. 17 W., Sec. 11, SE. 1/4; about 1/4 mile south of the A. Irvin home — Drilled: Sept. 15, 16, 1941

Elevation: 290 ft. — Water level: 35.5 ft.

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Soil
			Tuscaloosa formation
2	7.0	6.6	Clay, red-brown and gray mixture; contains much very fine sand; Sample 1
3	21.0	14.0	Clay, light-gray and rusty reddish-brown; contains fine sand; Sample 2
4	24.0	3.0	Clay, sandy, light-gray; some rust spots
5	27.0	3.0	Sand, gray; yellow and black rust and carbonaceous stains; micaceous
6	28.0	1.0	Clay and sand, rusty-brown
7	33.5	5.5	Sand, very fine gray and rusty brownish-yellow micaceous

W. U. Johnson Property

Test Hole P71

Location: T. 15 S., R. 17 W., Sec. 18; southern part, east side of road about 200 yds. south of bridge over branch — Drilled: Dec. 3, 1941

Elevation: 300 ft. ± — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.0	1.0	Soil, sandy
2	3.0	2.0	Sand, red-brown
			Tuscaloosa formation
3	7.5	4.5	Clay, light-gray; contains fine sand; Sample 1
4	12.5	5.0	Clay shale, gray rusty very sandy; or clayey sand, brown, shaly, slightly micaceous
5	17.7	5.2	Clay, brownish-gray sandy rusty shaly
6	25.4	7.7	Clay, micaceous bluish-gray shaly, very silty; Sample 2

FRANK GLASS PROPERTY

TEST HOLE P72

Location: T. 12 S., R. 17 W., Sec. 14, southern part Drilled: Dec. 16, 17, 1941

Elevation: 475 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, black loam
			Eutaw formation
2	18.3	17.8	Sand, red-brown and gray
3	19.3	1.0	Bentonite and shale

EB MEEK PROPERTY

TEST HOLE B75

Location: T. 14 S., R. 7 E., Sec. 4, SE. 1/4; 100 yds. northwest of the old Meek home, 20 feet west of an old road, and on the hillside under a beach tree
Drilled: Dec. 30, 1941

Elevation: 300 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, gray sandy loam
			Eutaw formation, Tombigbee Sand member
2	5.0	4.5	Sand, brown
3	6.5	1.5	Bentonite, cream-colored; Sample 1
4	11.5	5.0	Sand, brownish-gray; Sample 2

CENTRAL GROVE CHURCH PROPERTY

TEST HOLE P80

Location: T. 12 S., R. 7 E., Sec. 30, SW. 1/4; 40 yds. south of Central Grove Church, and 20 yds. west of the road, under a post oak tree
Drilled: Oct. 6, 1941

Elevation: 330 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.8	0.8	Soil, dark sandy loam
			Selma formation
2	13.0	12.2	Clay, light-gray and brown mottled; Sample 1
3	15.5	2.5	Chalk, clayey and sandy dull white; Sample 2

Wesley Meek Property

Test Hole F81

Location: T. 14 S., R. 7 E., Sec. 4, SW. 1/4; 275 yds. southwest of the Meek home Drilled: Dec. 30, 1941

Elevation: 300 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.3	0.3	Soil, gray sandy loam
			Eutaw formation, Tombigbee Sand member
2	1.5	1.2	Sand, grayish-brown
3	8.0	6.5	Clay and sand, brown
4	11.3	3.3	Sand and clay, brown and gray
5	19.2	7.9	Sand, brown
6	20.3	1.1	Sand and bentonite
7	21.0	0.7	Bentonite

Doctor Underwood Proferty

Test Hole P81

Location: T. 12 S., R. 6 E., Sec. 25, NE. 1/4; 8 ft. north of Center Grove Road, 200 yds. northwest of the Underwood home Drilled: Oct. 6, 1941

Elevation: 335 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	0.5	0.5	Soil, dark sandy loam
			Selma formation
1	6.8	6.3	Clay, gray and red-brown sandy, calcareous; Sample 1
2	10.5	3.7	Clay, bluish-white and rusty brown, black-streaked sandy, calcareous; Sample 2

Chaffin Property

Test Hole P85

Location: T. 12 S., R. 6 E., Sec. 25, NW. 1/4; west of Highway 45E 250 yds. on Center Grove Road, north of road 15 ft. Drilled: Oct. 6, 1941

Elevation: 320 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Soil, dark sandy loam
			Selma formation
2	10.0	9.6	Clay, gray and brown

T. E. Martin Property

Test Hole P88

Location: T. 12 S., R. 6 E., Sec. 30, SE. 1/4 (corner); 3/4 mile southeast of the Martin home, and 35 yds. north of Highway 41 Drilled: Oct. 8, 9, 1941

Elevation: 330 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Soil, dark sandy loam
			Selma formation
2	3.2	2.8	Clay, brown and gray very sandy; or sand, fine, rusty, clayey or silty
3	11.0	7.8	Clay, gray and brown and yellow very sandy; some chalk lumps
4	13.2	2.2	Chalk, gray clayey and sandy; Sample 1
5	27.5	14.3	Chalk, light-gray, less clayey and sandy than interval 4; Sample 2
6	31.0	3.5	Chalk, clayey and sandy; light "blue rock"; Sample 3

Orville Stockton Property

Test Hole P90

Location: T. 12 S., R. 7 E., Sec. 33, SW. 1/4 Drilled: Oct. 1, 1941

Elevation: 335 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Selma formation
1	4.0	4.0	Chalk, dull white clayey and sandy; Sample 1
2	7.5	3.5	Chalk, bluish-gray sandy and clayey; Sample 2

ALLISON CROUCH PROPERTY

TEST HOLE P92

Location: T. 12 S., R. 7 E., Sec. 32, south-central part; 40 yds. west of the Crouch home and 20 yds. south of Highway 41 Drilled: Nov. 8, 1941

Elevation: 315 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.2	0.2	Soil, dark clay loam
			Selma formation
2	2.0	1.8	Clay, mottled red rust-brown and gray; sandy and calcareous
3	10.5	8.5	Clay, gray rusty calcareous; Sample 1
4	13.6	3.1	Chalk, impure clayey and sandy; whitish-gray; Sample 2

J. I. ALLISON PROPERTY

TEST HOLE P95

Location: T. 12 S., R. 7 E., Sec. 31; 40 yds. south of Highway 41, 50 yds. north of pond in pasture, by oak tree Drilled: Nov. 8, 1941

Elevation: 320 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.0	1.0	Soil, dark to gray clay loam
			Selma formation
2	7.5	6.5	Clay, sandy brownish-gray; Sample 1
3	9.0	1.5	Clay, blue-gray, brown-mottled; Sample 2
4	11.0	2.0	Chalk, impure clayey and sandy brownish-gray; Sample 3

CHARLES COX PROPERTY

TEST HOLE B99

Location: T. 12 S., R. 17 W., Sec. 10, NE. 1/4 Drilled: Jan. 29, 1942

Elevation: 380 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, brown sandy loam
			Eutaw formation
2	4.5	4.0	Sand, red-brown
3	9.0	4.5	Bentonite

Mrs. Mary Murphree Property

Test Hole P99

Location: T. 13 S., R. 6 E., Sec. 5, NE. 1/4; 1/2 mile southwest of Highway 41 across James Creek on top of hill Drilled: Oct. 8, 1941

Elevation: 325 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	0.3	0.3	Soil, gray sandy and clayey loam
			Selma formation
1	5.8	5.5	Clay, gray chalky and sandy, or chalk, clayey and sandy; Sample 1
2	7.0	1.2	Clay, gray and yellow; lime and sand; Sample 2
3	10.8	3.8	Clay, gray limy and sandy; or chalk, clayey; Sample 3
4	12.5	1.7	Chalk, blue and gray shaly, sandy; Sample 4

Jim Baker Property

Test Hole P105

Location: T. 14 S., R. 7 E., Sec. 6, NE. 1/4; 1 mile north of the Baker old store, 20 yds. west of Highway 45E, 100 yds. south of where Okolona road leaves Highway 45E Drilled: Nov. 12, 1941

Elevation: 310 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Soil, gray to dark sandy and clayey loam
			Selma formation
2	7.0	6.6	Clay, gray slightly rusty sandy; Sample 1
3	10.6	3.6	Clay, very sandy yellow and gray; Sample 2
4	14.7	4.1	Clay, limy and sandy brown and some gray; Sample 3
5	15.7	1.0	Chalk, sandy and clayey gray; contains shell fragments; Sample 4

MRS. NICHOLS PROPERTY

TEST HOLE P107

Location: T. 14 S., R. 6 E., Sec. 5, NW. 1/4 Drilled: Nov. 25, 1941

Elevation: 300 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Soil, gray to dark clayey loam
			Selma formation
2	9.0	8.6	Clay, brown, gray, and yellow; mottled with iron rust
3	10.0	1.0	Limy clay, brown and gray, with black buckshot

JNO. C. WICKS PROPERTY

TEST HOLE P108

Location: T. 14 S., R. 7 E., Sec. 17, SW. 1/4; 2 1/2 miles north of Aberdeen, 30 yds. east of Highway 45E; 150 yds. south of the C. W. Grant store
Drilled: Nov. 24, 25, 1941

Elevation: 280 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, brown loam
			Selma formation
2	1.0	0.5	Clay, light-brown and gray sandy
3	7.4	6.4	Clay, gray; mottled with brown
4	13.0	5.6	Chalk, sandy yellowish to brownish-gray

G. C. PAINE EST. PROPERTY

TEST HOLE P111

Location: T. 14 S., R. 6 E., Sec. 22, SW. corner; 35 yds. north of Highway No. 8; 30 yds. east of road running north to Egypt Drilled: Oct. 24, 1941

Elevation: 280 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.0	1.0	Soil, brown sandy loam
			Selma formation
2	3.5	2.5	Clay, gray; somewhat rusty, sandy
3	10.0	6.5	Clay, gray and yellow, rusty; large sample sandy
4	11.0	1.0	Clay, light brownish-gray sandy

Alice Strong Property

Test Hole P113

Location: T. 15 S., R. 7 E., Sec. 12, NW. 1/4; 60 yds. northwest of the Strong home Drilled: Dec. 9, 1941

Elevation: 190 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	1.0	1.0	Soil, sandy loam
			Eutaw formation, Tombigbee Sand member
2	5.5	4.5	Sand, yellowish-brown
3	8.8	3.3	Sand, red and gray
4	14.0	5.2	Sand, brown
5	16.8	2.8	Sand, grayish-brown
6	17.8	1.0	Sand, gray
7	19.0	1.2	Sand, brown
8	22.0	3.0	Bentonite, blue; small cloth bag
9	27.0	5.0	Sand, blue

Alice Strong Property

Test Hole P114

Location: T. 15 S., R. 7 E., Sec. 12, NW. 1/4; 220 yds. west of the Strong home Drilled: Dec. 9, 1941

Elevation: 180 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.5	0.5	Soil, sandy loam
			Eutaw formation, Tombigbee Sand member
2	4.0	3.5	Sand, reddish-brown
3	8.5	4.5	Bentonite, grayish
4	10.5	2.0	Sand, brown

Frank Fears Property

Test Hole P123

Location: T. 12 S., R. 9 E., Sec. 8, SW. 1/4; some 200 yds. north of road, and a little north of a gravel pit Drilled: Jan. 15, 1942

Elevation: 280 ft. Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
	0.2	0.2	Soil, sandy loam
			Pleistocene terrace?
1	11.2	11.0	Sand; various colors, associated with some gravel
			Tuscaloosa formation
2	11.8	0.6	Sand and clay, white and brown
3	12.5	0.7	Bentonite, whitish sandy
4	13.7	1.2	Bentonite, blue sandy
5	16.1	2.4	Clay, brown and gray; some rock
6	20.0	3.9	Sand, blue clayey

Old Gordon Place (Crews) Property

Test Hole P143

Location: T. 13 S., R. 17 W., Sec. 23, SE. 1/4; 75 yds. southeast of house
Drilled: January 7, 1942

Elevation: 400 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.2	0.2	Soil, sandy loam
			Eutaw formation
2	5.5	5.3	Sand and clay, brown
3	6.6	1.1	Sand, bentonitic
4	8.3	1.7	Bentonite
5	9.5	1.2	Sand, brown

Old Gordon Place (Crews) Property

Test Hole P144

Location: T. 13 S., R. 17 W., Sec. 23, SE. 1/4; 250 yds. northeast of house
Drilled: Jan. 7, 1942

Elevation: 400 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Recent formation
1	0.4	0.4	Soil, sandy loam
			Eutaw formation
2	4.5	4.1	Sand and clay, brown
3	6.6	2.1	Sand, brown
4	9.0	2.4	Sand, gray
5	10.0	1.0	Sand, dark-brown
6	15.0	5.0	Sand, brown and gray
7	16.3	1.3	Sand and bentonite
8	18.3	2.0	Bentonite
9	19.0	0.7	Sand rock, brown

Charles Cox Property

Test Hole P146

Location: T. 12 S., R. 17 W., Sec. 10, SW. 1/4; 300 yds. northeast of Cox home
Drilled: Jan. 29, 1942

Elevation: 380 ft. ± Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
	0	0	Surface
			Eutaw formation
1	5.0	5.0	Sand and sand rock, brown
2	7.0	2.0	Sand, gray
3	9.6	2.6	Sand and sand rock, dark-brown
4	14.6	5.0	Bentonite

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Acknowledgment is hereby made of assistance given the mineral survey of Monroe County.

The County Board of Supervisors provided transportation and other facilities for the carrying on of the field investigations. The late Work Projects Administration provided the laborers for the drill prospecting and the taking of samples, and the officials of that agency furthered the project in various ways. The Mississippi State Geological Survey, besides furnishing most of the equipment used, sponsored and directed the Monroe County survey in its usual efficient manner, and did most of the editing incident to the preparation of the manuscript for the printer.

Numerous citizens helped the survey in one way or another, and although space can not be given here for a statement of the specific contribution of every individual concerned, certain people, who showed a constant interest in the progress of the work and promoted it very materially, are given special mention. Mr. C. M. Harrison, president of the Bank of Amory, was one of the foremost in efforts to initiate a geological and mineral resources survey of the county, and was at all times an active supporter of it after it was begun. He provided office and storage space; made available to the geologist in charge his complete file of papers relating to the drilling for oil and gas several years ago; passed along to the survey much miscellaneous information concerning the mineral substances of the county, and furthered the work in many other ways. Mr. P. J. MacAlpine, drilling contractor, who has directed the drilling of many wells in Monroe County, gave the writer the benefit of his thorough familiarity with the history of the local wells, and supplied the logs of many of these wells. Mr. H. G. D'Spain, manager of the Mississippi Public Service Company, kindly gave the writer permission to examine the company records, from which he obtained much information concerning the old gas wells. Mr. Ritter, of the Monroe County Electric Power Association, provided a map showing the distribution of the power lines in the county. Mr. E. L. Puckett, of the Amory Sand and Gravel Company, supplied information concerning the company sand and gravel business. Other Amory citizens who should be mentioned are Mr. S. J. Collier, Mr. Bentley, and Mr. Arch Dalrymple.

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Inasmuch as the mineral resources survey of Monroe County has been so truly a cooperative work, a due regard for fairness ana completeness would require that many other names should be mentioned, but space will not permit. However, acknowledgment of the interest showed by the field force and the conscientious effort they made to do their work intelligently and thoroughly should not be omitted.

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TESTS

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

INTRODUCTION

The mineral resources of Monroe County, as represented by the materials submitted for testing, comprise three general types. They are: the Ceramic Clays, the Bentonites, and the Argillaceous Limestones. Of the three, only bentonite is being mined at the present time for commercial purposes.

The Ceramic Clays have been classified as: Pottery, Brick, and Tile Clays; Bond Clays; and Miscellaneous Clays. The Pottery, Brick, and Tile Clays are probably the most valuable. The warm colors of salmon and buff of the fired clays are very desirable for structural clay products. The bond clays, although possessing high dry strength, have limited ceramic possibilities due to their high silica content. The Miscellaneous Clays are of four varieties that do not correspond with the other two general classifications.

Bentonite is of considerable local interest due to the mining activity of the American Colloid Co. and the leasing of bentonite deposits by various commercial interests. The samples submitted for testing are from a number of prospecting test holes and do not include the material now being mined and processed. In the preceding part of this report Vestal has discussed at length the properties, characteristics, and uses of bentonite. In the laboratory no attempt was made to evaluate the several samples according to the numerous uses for bentonite as methods of testing are not standardized but are rather specialized and peculiar to producers and consumers of the product. The quality of a single type of bentonite, such as that found in Monroe County, may be evaluated by the purity of the sample as determined by standard screen and chemical analyses.

The Argillaceous Limestones are of importance by virtue of the wide distribution, abundance, and varieties found in the County. Their uses are limited because of the generally low calcium carbonate content. The high calcium carbonate Arcola limestone referred to by Vestal in the preceding part of this report was not sampled for testing.

CERAMIC CLAYS—POTTERY, BRICK, AND TILE CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage Volume in percent	Drying shrinkage Linear in percent	Modulus of rupture in pounds per square inch	Color
P12	1–3	31.90	39.51	15.42	618	Grayish tan
P17	1	27.58	32.75	12.39	455	Medium gray
P30	1	31.62	35.48	13.60	410	Yellowish gray
P32	1	34.60	44.80	17.97	795	Medium gray
P32	2–3	39.32	30.35	11.36	437	Dark gray
P42	1	32.10	39.50	15.42	635	Gray
P50	OC1	28.40	28.40	11.25	403	Light gray
P50	2	31.35	35.63	13.64	496	Light gray
P57	1	28.47	26.71	9.84	320	Yellowish gray
P57	2–3	28.90	31.60	11.89	290	Tan
P58	1	36.93	43.45	17.30	523	Dark gray
P58	2–3	30.38	37.87	14.68	557	Medium gray
P58	4	27.87	32.35	12.22	520	Gray
P59	3	37.95	43.93	17.53	585	Gray
P60	2–3	28.95	30.68	11.51	377	Medium gray
P63	2	43.45	30.18	11.29	382	Dark gray

SCREEN ANALYSES

SAMPLE P12 1-3

Retained on screen	Percent	Character of residue
60	3.14	Abundance of limonitic micaceous clay nodules; considerable quantity of micaceous gray nodules; small amounts of ferruginous material and quartz.
100	3.94	Abundance of micaceous gray clay nodules; considerable quantity of limonitic clay nodules; small amount of quartz; trace of ferruginous material.
250	9.25	Abundance of gray clay nodules; considerable quantity of limonitic nodules; small amount of quartz; trace of muscovite.
Cloth	83.67	Clay substance including residue from above.

Sample P17 1

Retained on screen	Percent	Character of residue
60	2.24	Abundance of limonitic argillaceous nodules; considerable quantity of limonitic clay nodules; small amount of quartz.
100	1.69	Abundance of limonitic clay nodules; considerable quantities of quartz and muscovite; small amount of ferruginous material.
250	9.80	Abundance of quartz; small amounts of white clay and some limonitic stained nodules; trace of muscovite.
Cloth	86.27	Clay substance including residue from above.

Sample P30 1

Retained on screen	Percent	Character of residue
60	.60	Abundance of gray clay nodules; considerable quantity of limonitic clay nodules; small amount of plant fragments; traces of quartz and muscovite.
100	2.74	Abundance of clay nodules; considerable quantity of quartz; small amounts of muscovite and limonitic material; trace of plant fragments.
250	5.94	Abundance of quartz; considerable quantity of clay nodules; small amount of muscovite.
Cloth	90.72	Clay substance including residue from above.

Sample P32 1

Retained on screen	Percent	Character of residue
60	4.24	Abundance of micaceous gray clay nodules; traces of ferruginous material and plant fragments.
100	4.30	Abundance of micaceous gray clay nodules; traces of ferruginous material and plant fragments.
250	9.88	Abundance of gray clay nodules; considerable quantity of quartz; small amount of muscovite; trace of ferruginous material.
Cloth	81.58	Clay substance including residue from above.

SAMPLE P32 2-3

Retained on screen	Percent	Character of residue
60	1.20	Abundance of lignitic micaceous clay nodules; considerable quantity of limonitic clay nodules; traces of pyrite and quartz.
100	4.90	Abundance of lignitic micaceous clay nodules; small amounts of quartz; limonitic stained clay nodules, and muscovite.
250	9.10	Abundance of lignitic clay nodules; considerable quantity of quartz; small amount of muscovite.
Cloth	84.80	Clay substance including residue from above.

SAMPLE P42 1

Retained on screen	Percent	Character of residue
60	2.64	Abundance of lignitic micaceous gray clay nodules; considerable quantity of limonitic clay nodules; small amount of siderite; trace of lignite.
100	3.60	Abundance of micaceous gray clay nodules; small amount of limonitic clay nodules; small amount of lignite; traces of quartz and muscovite.
250	6.10	Abundance of gray clay nodules; considerable quantity of muscovite; trace of limonite.
Cloth	87.66	Clay substance including residue from above.

SAMPLE P50 2

Retained on screen	Percent	Character of residue
60	.35	Abundance of white clay nodules, some stained with limonite; considerable quantity of quartz; small amount of ferruginous rock; trace of plant fragments.
100	.50	Abundance of quartz; considerable quantity of clay nodules, some stained with limonite; small amount of ferruginous rock.
250	.65	Abundance of quartz; considerable quantity of clay nodules; small amount of limonite, ferruginous material, and muscovite.
Cloth	98.50	Clay substance including residue from above.

Sample P57 1

Retained on screen	Percent	Character of residue
60	10.05	Abundance of limonitic stained clay nodules; considerable quantity of hematite; small amount of quartz.
100	7.37	Abundance of limonitic stained clay nodules; considerable quantity of quartz; small amount of hematite.
250	9.16	Abundance of limonitic stained nodules; considerable quantity of quartz; small amount of hematite.
Cloth	73.42	Clay substance including residue from above.

Sample P57 2-3

Retained on screen	Percent	Character of residue
60	8.84	Abundance of clay-ironstones of siderite; considerable quantity of limonitic clay nodules; small amount of quartz.
100	5.30	Abundance of white clay nodules; considerable quantity of clay nodules stained with limonite; small amount of quartz; trace of ferruginous rock.
250	4.98	Abundance of white clay nodules with some limonitic stained nodules; considerable quantity of quartz; trace of ferruginous material.
Cloth	81.24	Clay substance including residue from above.

Sample P58 1

Retained on screen	Percent	Character of residue
60	18.76	Abundance of lignitic clay nodules; considerable quantity of light-gray clay nodules; small amount of carbonaceous material.
100	10.28	Abundance of lignitic clay nodules; considerable quantity of white clay nodules; small amounts of lignite and quartz; traces of muscovite.
250	10.02	Abundance of lignitic clay nodules; considerable quantity of light-gray nodules; small amount of quartz; traces of muscovite and limonite.
Cloth	60.94	Clay substance including residue from above.

SAMPLE P58 2-3

Retained on screen	Percent	Character of residue
60	3.30	Abundance of gray clay nodules; considerable quantity of "clay-ironstones" or siderite; small amounts of ferruginous rock and quartz.
100	5.74	Abundance of gray clay nodules; considerable quantity of siderite; small amount of quartz; trace of muscovite.
250	8.71	Abundance of quartz; considerable quantity of gray clay nodules; small amounts of ferruginous material and muscovite.
Cloth	82.25	Clay substance including residue from above.

SAMPLE P58 4

Retained on screen	Percent	Character of residue
60	7.70	Abundance of gray micaceous clay nodules; considerable quantity of quartz; small amounts of ferruginous material, pyrite, and carbonaceous material.
100	10.82	Abundance of quartz; considerable quantity of gray micaceous clay nodules; small amount of ferruginous material; trace of pyrite.
250	9.25	Abundance of gray clay nodules; considerable quantity of quartz; small amount of muscovite; trace of ferruginous material.
Cloth	72.23	Clay substance including residue from above.

SAMPLE P59 3

Retained on screen	Percent	Character of residue
60	5.82	Abundance of micaceous gray clay nodules; small amount of limonitic clay nodules; trace of carbonaceous material.
100	4.89	Abundance of micaceous gray clay nodules; small amount of limonitic clay nodules; trace of carbonaceous material.
250	5.86	Abundance of gray clay nodules; small amount of limonitic clay nodules; traces of muscovite and carbonaceous material.
Cloth	83.43	Clay substance including residue from above.

SAMPLE P60 2-3

Retained on screen	Percent	Character of residue
60	2.86	Abundance of "clay-ironstones" or siderite; considerable quantity of gray clay nodules; small amounts of limonitic clay nodules and quartz; trace of hematite.
100	4.59	Abundance of gray, white, and yellow clay nodules; considerable quantity of quartz; small amount of muscovite.
250	15.95	Abundance of quartz; considerable quantity of clay nodules; trace of hematite.
Cloth	76.60	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSES

Sample P12 1-3

Ignition loss	6.33	Lime, CaO	0.15
Silica, SiO_2	67.26	Magnesia, MgO	0.63
Alumina, Al_2O_3	19.20	Manganese, MnO_2	0.06
Iron oxide, Fe_2O_3	3.78	Alkalies, (K_2O, Na_2O)	0.63
Titania, TiO_2	1.28		

Sample P17 1

Ignition loss	6.34	Lime, CaO	0.08
Silica, SiO_2	67.78	Magnesia, MgO	0.83
Alumina, Al_2O_3	19.87	Manganese, MnO_2	0.08
Iron oxide, Fe_2O_3	3.06	Alkalies, (K_2O, Na_2O)	0.62
Titania, TiO_2	0.98		

Sample P30 1

Ignition loss	7.60	Lime, CaO	Trace
Silica, SiO_2	64.67	Magnesia, MgO	0.67
Alumina, Al_2O_3	20.73	Manganese, MnO_2	None
Iron oxide, Fe_2O_3	4.13	Alkalies, (K_2O, Na_2O)	0.73
Titania, TiO_2	1.09		

Sample P32 1

Ignition loss	6.40	Lime, CaO	0.11
Silica, SiO_2	67.70	Magnesia, MgO	0.80
Alumina, Al_2O_3	21.08	Manganese, MnO_2	None
Iron oxide, Fe_2O_3	2.06	Alkalies, (K_2O, Na_2O)	0.64
Titania, TiO_2	1.28		

Sample P32 2-3

Ignition loss	6.98	Lime, CaO	0.25
Silica, SiO_2	72.73	Magnesia, MgO	0.81
Alumina, Al_2O_3	13.88	Manganese, MnO_2	0.13
Iron oxide, Fe_2O_3	3.03	Alkalies, (K_2O, Na_2O)	0.70
Titania, TiO_2	1.16		

Sample P42 1

Ignition loss	6.55	Lime, CaO	Trace
Silica, SiO_2	68.28	Magnesia, MgO	0.73
Alumina, Al_2O_3	19.44	Manganese, MnO_2	0.07
Iron oxide, Fe_2O_3	3.01	Alkalies, (K_2O, Na_2O)	0.63
Titania, TiO_2	1.31		

Sample P50 2

Ignition loss	6.83	Lime, CaO	None
Silica, SiO_2	65.95	Magnesia, MgO	0.50
Alumina, Al_2O_3	22.96	Manganese, MnO_2	None
Iron oxide, Fe_2O_3	2.00	Alkalies, (K_2O, Na_2O)	0.86
Titania, TiO_2	0.72		

SAMPLE P57 1

Ignition loss	4.78	Lime, CaO	None
Silica, SiO_2	74.92	Magnesia, MgO	0.36
Alumina, Al_2O_3	14.06	Manganese, MnO_2	None
Iron oxide, Fe_2O_3	4.20	Alkalies, (K_2O, Na_2O)	0.39
Titania, TiO_2	1.35		

SAMPLE P57 2-3

Ignition loss	7.11	Lime, CaO	None
Silica, SiO_2	64.53	Magnesia, MgO	0.25
Alumina, Al_2O_3	19.59	Manganese, MnO_2	0.11
Iron oxide, Fe_2O_3	6.90	Alkalies, (K_2O, Na_2O)	0.43
Titania, TiO_2	1.02		

SAMPLE P58 1

Ignition loss	8.08	Lime, CaO	0.21
Silica, SiO_2	63.59	Magnesia, MgO	0.49
Alumina, Al_2O_3	22.01	Manganese, MnO_2	0.05
Iron oxide, Fe_2O_3	3.17	Alkalies, (K_2O, Na_2O)	0.59
Titania, TiO_2	1.22		

SAMPLE P58 2-3

Ignition loss	6.41	Lime, CaO	Trace
Silica, SiO_2	67.87	Magnesia, MgO	0.63
Alumina, Al_2O_3	18.68	Manganese, MnO_2	0.15
Iron oxide, Fe_2O_3	4.73	Alkalies, (K_2O, Na_2O)	0.34
Titania, TiO_2	1.04		

SAMPLE P58 4

Ignition loss	5.81	Lime, CaO	Trace
Silica, SiO_2	72.25	Magnesia, MgO	0.53
Alumina, Al_2O_3	15.01	Manganese, MnO_2	0.04
Iron oxide, Fe_2O_3	4.23	Alkalies, (K_2O, Na_2O)	0.88
Titania, TiO_2	0.85		

SAMPLE P59 3

Ignition loss	7.74	Lime, CaO	None
Silica, SiO_2	63.38	Magnesia, MgO	0.52
Alumina, Al_2O_3	24.10	Manganese, MnO_2	Trace
Iron oxide, Fe_2O_3	2.52	Alkalies, (K_2O, Na_2O)	0.60
Titania, TiO_2	0.98		

SAMPLE P60 2-3

Ignition loss	6.81	Lime, CaO	None
Silica, SiO_2	68.80	Magnesia, MgO	0.35
Alumina, Al_2O_3	19.48	Manganese, MnO_2	0.04
Iron oxide, Fe_2O_3	3.12	Alkalies, (K_2O, Na_2O)	0.54
Titania, TiO_2	0.89		

B. F. Mandlebaum, analyst

PYRO-PHYSICAL PROPERTIES

Test Holes P12, P17, P30, P32

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
P12 1-3	02	16.17	8.25	1.96	2.34	9.86	3.42	4437	Salmon buff St. H.
	1	15.46	7.70	2.08	2.38	11.70	4.06	3707	Salmon buff
	3	14.47	7.00	2.07	2.43	15.29	5.38	4737	Salmon buff
	5	12.93	6.42	2.02	2.32	11.60	4.03	4160	Salmon buff
	7	7.86	3.77	2.08	2.26	15.35	5.38	2382	Gray buff
	9	4.66	2.27	2.05	2.16	13.54	4.72	N.D.	Gray buff
	11	11.80	5.87	2.02	2.28	12.49	4.35	3385	Gray buff
P17 1	02	16.92	8.49	1.99	2.40	8.67	2.99	3057	Lt. buff St. H.
	1	18.99	9.65	1.97	2.43	7.62	2.60	3142	Lt. buff
	3	12.84	6.25	2.06	2.36	11.33	3.92	3157	Buff
	5	12.55	6.13	2.04	2.35	10.75	3.70	3127	Buff
	7	9.28	4.47	2.08	2.30	12.22	4.24	2841	Gray buff
	9	10.26	4.90	2.08	2.36	12.60	4.39	3837	Gray buff
	11	9.22	4.50	2.06	2.27	11.78	4.10	4337	Gray buff
P30 1	02	20.83	10.95	1.92	2.44	11.13	3.85	2467	Lt. buff St. H.
	1	22.28	11.62	1.92	2.46	10.93	3.77	2114	Lt. buff
	3	16.55	8.27	2.00	2.41	14.42	5.05	2304	Salmon buff
	5	15.45	7.67	2.00	2.39	14.98	5.27	2806	Salmon buff
	7	14.99	7.47	2.00	2.37	13.65	4.76	4022	Salmon buff
	9	11.53	7.58	2.07	2.36	17.16	6.10	5247	Buff
	11	11.24	5.51	2.04	2.31	16.52	5.83	5520	Buff
P32 1	02	18.10	9.32	1.94	2.36	8.85	3.02	3570	Lt. buff St. H.
	1	19.33	9.93	1.95	2.41	9.17	3.17	3830	Lt. buff
	3	14.91	7.40	1.99	2.36	11.57	4.03	4555	Lt. buff
	5	12.85	6.62	2.00	2.30	11.46	3.99	1424	Lt. buff
	7	12.80	6.43	2.02	2.32	12.93	4.50	1908	Lt. buff
	9	13.58	6.62	2.05	2.37	13.88	4.87	4075	Buff
	11	13.47	6.46	2.06	2.38	13.99	4.90	4210	Buff
P32 2-3	02	28.53	16.24	1.75	2.46	2.38	0.81	1641	Grayish cream
	1	30.20	17.27	1.75	2.51	1.94	0.64	1881	Grayish cream
	3	26.52	16.68	1.80	2.45	4.49	1.52	2225	Grayish cream
	5	25.85	14.40	1.79	2.41	3.58	1.21	1923	Grayish cream
	7	25.78	14.25	1.81	2.44	5.35	1.80	2509	Grayish cream St. H.
	9	23.18	12.42	1.81	2.33	5.80	1.97	3136	Grayish cream
	11	25.17	13.83	1.82	2.43	5.72	1.94	2876	Buff

Test Holes P42, P50, P57

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in	Color and remarks
P42 1	02	22.30	11.91	1.87	2.41	5.09	1.73	2469	Buff *
	1	18.72	9.69	1.92	2.40	7.51	2.57	2974	Buff *
	3	20.33	10.44	1.87	2.38	6.08	2.08	4082	Buff * St. H.
	5	17.46	9.17	1.90	2.35	6.99	2.39	3947	Buff *
	7	14.40	7.27	1.98	2.34	10.11	3.49	2790	Gray buff *
	9	12.93	6.71	2.04	2.35	13.18	4.60	4347	Gray buff *
	11	18.85	10.17	1.84	2.24	3.40	1.15	3357	Dk. gray buff * Bl.
P50 OC1	02	21.33	11.23	1.88	2.46	7.47	2.57	2704	Lt. buff St. H.
	1	21.25	11.10	1.91	2.43	7.38	2.53	2621	Lt. buff
	3	17.95	9.05	1.99	2.42	10.34	3.56	3010	Lt. buff
	5	15.43	7.58	2.04	2.41	12.62	4.39	3067	Buff
	7	13.03	6.25	2.09	2.41	14.82	5.20	3667	Buff
	9	7.29	3.35	2.18	2.36	18.79	6.71	4452	Buff
	11	10.21	4.80	2.15	2.39	17.46	6.21	5310	Gray Bl.
P50 2	02	17.02	8.37	2.05	2.45	12.46	4.35	3306	Buff St. H.
	1	13.63	7.19	2.09	2.46	14.65	5.12	3421	Buff
	3	14.01	6.64	2.11	2.45	15.80	5.57	4270	Buff
	5	15.92	7.68	2.05	2.46	12.55	4.35	4517	Buff
	7	10.99	5.10	2.17	2.42	18.00	6.40	5380	Gray buff
	9	1.86	0.82	2.26	2.35	21.97	7.95	5563	Gray buff
	11	9.15	4.41	2.10	2.30	16.44	5.80	6227	Dk. gray Bl.
P57 1	02	30.40	17.00	1.79	2.58	0.83	0.27	1724	Salmon
	1	30.12	16.73	1.81	2.59	1.25	0.40	1304	Salmon
	3	29.47	16.19	1.82	2.58	1.81	0.60	1289	Salmon
	5	29.38	16.25	1.81	2.57	2.08	0.70	1293	Salmon
	7	26.93	14.56	1.85	2.53	4.29	1.45	1456	Salmon
	9	26.00	14.03	1.86	2.51	4.47	1.52	1474	Salmon
	11	27.25	14.84	1.83	2.52	3.42	1.15	3122	Salmon buff Not St. H.
P57 2-3	02	29.93	16.00	1.85	2.62	5.27	1.80	2740	Salmon buff
	1	25.85	13.35	1.94	2.62	9.43	3.24	2215	Salmon buff St. H.
	3	24.57	12.57	1.96	2.60	11.44	3.92	2960	Salmon buff
	5	24.25	12.55	1.93	2.57	8.72	3.34	2311	Salmon buff
	7	24.02	11.95	1.95	2.56	10.40	3.60	2067	Salmon buff
	9	19.80	10.21	1.98	2.48	11.69	4.06	2890	Buff
	11	19.75	9.91	1.99	2.49	12.08	4.21	4280	Buff

TEST HOLES P58, P59, P60, P63

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
P58 1	02	25.27	13.34	1.89	2.53	11.05	3.81	935	Buff	St. H.
	1	24.35	12.84	1.91	2.54	12.19	4.24	1392	Buff	
	3	21.08	10.78	1.95	2.51	13.87	4.87	1467	Buff	
	5	23.93	11.98	1.91	2.48	11.61	4.03	1425	Buff	
	7	20.05	10.34	1.94	2.41	13.16	4.61	1719	Buff	
	9	18.00	9.32	1.94	2.35	13.36	4.68	3952	Buff	
	11	16.61	8.35	1.97	2.37	14.19	4.98	4565	Buff	
P58 2-3	02	20.22	10.32	1.98	2.48	7.71	2.64	3057	Salmon buff	St. H.
	1	19.03	9.58	1.99	2.45	8.41	2.88	2695	Salmon buff	
	3	17.37	8.79	1.99	2.41	8.57	2.95	3212	Salmon buff	
	5	17.30	8.72	1.98	2.42	8.14	2.78	3408	Salmon buff	
	7	14.66	7.23	2.03	2.38	10.27	3.56	3765	Dk. buff	
	9	15.93	7.81	2.07	2.38	10.92	3.77	3660	Dk. buff	
	11	13.28	6.47	2.05	2.37	10.10	3.50	4433	Dk. buff	
P58 4	02	26.38	13.92	1.90	2.58	2.44	0.81	1924	Salmon buff *	St. H.
	1	25.12	13.05	1.92	2.58	3.85	1.28	1962	Salmon buff *	
	3	24.72	12.84	1.93	2.53	4.02	1.35	2017	Salmon buff *	
	5	23.63	12.25	1.93	2.53	4.26	1.45	2321	Salmon buff *	
	7	21.57	11.00	1.96	2.50	5.71	1.94	2505	Salmon buff *	
	9	20.24	10.33	1.96	2.46	6.01	2.04	2309	Dk. buff *	
	11	21.68	10.89	1.98	2.52	5.93	2.01	2920	Dk. buff *	
P59 3	02	17.61	8.73	2.02	2.45	16.98	6.00	4812	Buff	St. H.
	1	15.49	7.48	2.07	2.46	18.95	6.74	4336	Buff	
	3	11.91	5.66	2.12	2.42	20.78	7.48	4524	Buff	
	5	10.81	5.03	2.13	2.41	22.03	7.95	1129	Buff	
	7	1.99	0.91	2.19	2.23	23.48	8.54	1432	Gray buff	
	9	9.00	4.39	2.07	2.26	20.15	7.21	5390	Gray buff	Cr.
P60 2-3	02	27.07	14.52	1.87	2.56	7.83	2.67	1468	Lt. buff	St. H.
	1	27.07	14.00	1.89	2.57	9.36	3.24	1914	Lt. buff	
	3	25.98	13.72	1.91	2.56	8.77	3.02	2326	Lt. buff	
	5	27.52	14.66	1.91	2.60	7.43	2.53	2652	Lt. buff	
	7	26.65	13.84	1.93	2.60	10.44	3.59	2795	Lt. buff	
	9	24.58	12.69	1.94	2.55	10.46	3.63	2745	Lt. buff	
	11	22.70	11.74	1.93	2.51	10.80	3.74	3770	Lt. buff	
P63 2	02	33.90	20.23	1.68	2.54	6.32	2.15	1801	Salmon	
	1	32.77	19.51	1.70	2.58	6.79	2.32	1665	Salmon	
	3	32.15	19.07	1.71	2.51	7.19	2.56	1771	Salmon	
	5	30.06	17.07	1.75	2.49	9.72	3.34	1897	Dull red	
	7	26.78	14.78	1.80	2.49	13.62	4.68	1838	Dull red	St. H.
	9	23.70	12.67	1.86	2.45	15.56	5.50	2771	Dull red	
	11	22.30	11.68	1.91	2.47	17.36	6.17	2412	Lt. brown	

Abbreviations: St. H., steel hard; Bl., bloated; Cr., cracked.
* Stained with calcium salts.

POSSIBILITIES FOR UTILIZATION

The Pottery, Brick, and Tile Clays are the salmon and buff burning variety which are further characterized by their long burning range, their good plastic, working, and drying properties and their moderately high dry and fired strengths. Chemical and screen analyses of 14 samples show the clays to be somewhat siliceous. The highest alumina content is 24.1 percent and the lowest is 13.88 percent. The general average alumina content is approximately 20 percent or about half that of kaolinite. Clays of this type are well adapted for use in making many valuable structural clay products and some of the clays are particularly suited for making pottery.

Clays represented by samples P30-1, P32-1, P50-2, P50-OC1, and P59-3 burn to clear even shades of buff and become steel hard at cone 02. Porosity and absorption values between cones 3 and 7 are moderately low and fairly uniform. The fired strengths are high except for two samples at cones 5 and 7. These would likely show improvement when burned and cooled at a slower rate. The five samples are suited for making stoneware, art pottery, flower pots, garden pottery, and faience. They may also be used for making structural clay products but are more valuable for pottery.

The remaining eleven samples are particularly suited for making brick and tile. The fired colors are of greater variation than the pottery clays and in general the porosity and absorption values of the clays are higher. Products, such as face brick, hollow tile, flue lining, facing tile, load bearing tile, and drain tile, could be easily made from these clays.

CERAMIC CLAYS—BOND CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
P2	1–4	35.78	46.17	18.67	573	Dark gray
P7	2–4	40.40	54.18	22.92	873	Dark gray
P35	2–4	39.13	53.67	22.63	654	Black
P42	2	35.25	48.33	12.23	471	Dark gray
P53	1–3	38.10	38.10	17.14	589	Dark gray
P55	1	45.53	65.90	30.14	966	Dark gray
P59	1–2	37.55	46.23	18.67	652	Dark gray
P63	1	38.72	46.22	18.67	622	Dark gray
P66	1	44.12	64.17	28.99	918	Black
P66	2–3	39.97	48.10	19.64	605	Dark gray
P67	2	35.83	52.08	21.76	1032	Yellowish gray
P71	1	40.07	57.23	24.64	938	Dark gray
P71	2	40.30	52.30	21.87	893	Dark gray
P80	1	34.90	55.53	23.65	1047	Yellowish gray
P81	1	32.27	47.60	19.38	973	Yellowish gray
P81	2	35.00	52.97	22.25	1047	Yellowish gray
P85	1	31.55	54.63	23.14	1014	Yellowish gray
P92	1	35.35	55.63	23.71	1009	Yellowish gray
P95	1	37.10	57.62	24.87	1176	Yellowish gray
P105	1–2	33.82	54.07	22.86	926	Yellowish gray
P107	1	33.57	49.58	20.42	882	Yellowish gray
P108	1	34.65	55.58	23.71	1147	Yellowish gray
P111	1	38.53	63.23	28.34	968	Yellowish gray

SCREEN ANALYSIS

SAMPLE P66 1

Retained on screen	Percent	Character of residue
60	4.73	Abundance of gray clay nodules; considerable quantity of limonitic clay nodules; small amounts of dark lignitic clay nodules and ferruginous material.
100	5.74	Abundance of gray, white, and yellow clay nodules; small amount of lignitic material.
250	8.82	Abundance of gray, yellow, and white clay nodules; small amount of lignitic material.
Cloth	80.71	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSIS

SAMPLE P66 1

Ignition loss	10.27	Lime, CaO	0.51
Silica, SiO_2	53.61	Magnesia, MgO	0.70
Alumina, Al_2O_3	29.87	Manganese, MnO_2	0.03
Iron oxide, Fe_2O_3	3.39	Alkalies, (K_2O, Na_2O)	0.44
Titania, TiO_2	0.82		

B. F. Mandlebaum, analyst

PYRO-PHYSICAL PROPERTIES

TEST HOLES P2, P7, P35, P42, P53, P55, P59, P63, P66, P67, P71, P80, P81

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
P2 1-4	02	7.01	3.28	2.15	2.31	20.12	7.21	4727	Salmon buff* Cr.	St. H.
	1	5.59	2.61	2.15	2.31	20.12	7.21	2927	Salmon buff* Cr.	
	3	2.60	1.21	2.16	2.23	20.70	7.44	N.D.	Salmon buff* Cr.	
P7 2-4	02	15.86	8.46	1.86	2.21	8.00	2.74	2644	Salmon* Cr.	St. H.
	1	19.22	10.20	1.89	2.34	9.54	3.27	1766	Salmon* Cr.	
	3	15.85	8.35	1.90	2.26	9.44	3.24	N.D.	Salmon* Cr.	
P35 2-4	02	10.81	5.06	2.13	2.40	21.70	7.83	2837	Buff	St. H.
	1	19.17	9.44	2.03	2.52	17.47	6.21	345	Buff Cr.	
	3	5.33	2.45	2.14	2.25	21.93	7.91	N.D.	Buff Cr.	
P42 2	02	18.71	8.92	2.07	2.52	17.24	6.10	4115	Buff	St. H.
	1	15.08	7.00	2.16	2.55	21.57	7.79	1230	Buff Cr.	
	3	13.05	6.09	2.16	2.48	21.28	7.67	N.D.	Buff Cr.	
P53 1-3	02	16.13	8.21	1.96	2.34	18.55	6.59	2005	Yellowish gray* Cr.	St. H.
P55 1	02	15.87	9.32	1.71	2.03	–1.10	–0.37	290	Grayish yellow* Bl.	St. H.
	1	25.58	16.00	1.60	2.15	–7.51	–2.22	581	Grayish yellow* Bl.	
	3	22.72	13.62	1.67	2.16	–3.69	–1.25	N.D.	Grayish yellow* Bl.	
P59 1-2	02	18.92	9.37	2.02	2.49	16.28	5.76	3755	Salmon buff	St. H.
	1	23.05	11.87	1.94	2.50	12.77	4.46	2255	Salmon buff Cr.	
	3	15.84	7.56	2.08	2.47	18.70	6.67	N.D.	Salmon buff Cr.	
P63 1	02	11.74	3.24	2.11	2.39	20.95	7.52	3680	Salmon buff	St. H.
	1	15.67	7.60	2.08	2.47	18.23	6.48	4105	Salmon buff Cr.	
	3	16.54	8.05	2.05	2.46	18.17	6.48	N.D.	Salmon buff Cr.	
P66 1	02	5.06	2.33	2.18	2.31	24.42	8.90	1015	Buff* Cr.	St. H.
	1	11.02	5.08	2.15	2.38	22.58	8.18	N.D.	Buff* Cr.	
P66 2-3	02	23.23	12.19	1.90	2.48	13.60	4.76	4280	Buff	St. H.
	1	24.47	10.85	2.25	3.08	27.40	10.12	4657	Buff Cr.	
	3	20.16	10.08	1.98	2.56	16.97	6.02	N.D.	Buff Cr.	
P67 2	02	12.84	6.11	2.12	2.54	12.80	4.46	2409	Lt. red Cr.	St. H.
	1	15.40	7.16	2.15	2.54	13.47	4.72	1575	Lt. red Cr.	
	3	13.11	6.61	2.13	2.48	12.95	4.50	425	Lt. red Cr.	
P71 1	02	13.93	6.75	2.06	2.40	15.57	5.50	586	Salmon buff	St. H.
	1	13.12	6.24	2.10	2.42	16.94	5.98	839	Salmon buff Cr.	
	3	10.78	5.08	2.14	2.40	18.44	6.55	877	Salmon buff Cr.	
P71 2	02	25.32	21.50	1.17	1.60	–44.85	–17.97	978	Dull red* Bl.	St. H.
P80 1	02	21.04	10.67	1.94	2.51	3.23	1.08	2527	Lt. red Cr.	St. H.
	1	20.28	10.37	1.98	2.49	3.75	1.25	N.D.	Lt. red Cr.	
	3	19.71	9.98	1.98	2.51	3.93	1.32	N.D.	Lt. red Cr.	
P81 1	02	24.98	13.17	1.90	2.53	0.78	0.27	511	Lt. red Cr.	St. H.
	1	24.33	12.86	1.92	2.54	1.72	0.57	1652	Lt. red Cr.	
	3	25.03	13.03	1.91	2.56	1.74	0.57	N.D.	Lt. red Cr.	

TEST HOLES P81, P85, P92, P95, P105, P107, P108, P111

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks		
P81 2	02	22.57	11.58	1.93	2.50	3.34	1.11	2870	Lt. red	Cr.	St. H.
	1	22.57	11.45	1.97	2.53	4.41	1.49	404	Lt. red	Cr.	
	3	25.00	12.70	1.98	2.70	4.99	1.70	N.D.	Lt. red	Cr.	
P85 1	02	20.80	10.28	1.90	2.50	3.31	1.11	500	Lt. red	Cr.	St. H.
	1	21.88	10.77	1.96	2.48	3.04	1.01	N.D.	Lt. red	Cr.	
P92 1	02	20.17	10.33	1.95	2.45	4.92	1.64	N.D.	Lt. red	Cr.	St. H.
	1	20.12	10.12	1.98	2.49	6.29	2.15	316	Lt. red	Cr.	
	3	16.64	8.45	2.00	2.41	7.40	2.53	N.D.	Lt. red	Cr.	
P95 1	02	19.80	10.09	1.96	2.45	5.35	1.80	2500	Lt. red	Cr.	St. H.
	1	19.93	10.07	1.98	2.48	5.89	2.01	N.D.	Lt. red	Cr.	
	3	18.46	9.42	1.99	2.46	6.40	2.18	N.D.	Lt. red	Cr.	
P105 1-2	02	22.63	11.67	1.94	2.51	1.04	0.33	356	Lt. red	Cr.	St. H.
	1	22.60	11.52	1.97	2.53	2.05	0.67	331	Lt. red	Cr.	
	3	21.95	11.23	1.96	2.51	2.07	0.70	N.D.	Lt. red	Cr.	
P107 1	02	23.95	12.26	1.90	2.57	3.26	1.11	3540	Lt. red	Cr.	St. H.
	1	23.35	11.83	1.91	2.57	3.91	1.32	N.D.	Lt. red	Cr.	
	3	22.53	11.47	1.91	2.54	4.20	1.42	N.D.	Lt. red	Cr.	
P108 1	02	21.72	11.34	1.94	2.48	3.68	1.25	2303	Lt. red	Cr.	St. H.
	1	21.30	10.97	1.96	2.49	4.40	1.49	N.D.	Lt. red	Cr.	
P111 1	02	15.89	7.84	2.02	2.41	7.79	2.67	340	Lt. red*	Cr.	St. H.
	1	16.22	8.04	2.04	2.44	8.52	2.92	N.D.	Lt. red*	Cr.	

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

* Stained with calcium salts.

POSSIBILITIES FOR UTILIZATION

The Bond Clays are the red and salmon to buff burning group which have unusually high dry strengths. The clays shrink excessively on drying and crack on burning and are consequently unsuited for use as the sole constituent of ceramic products.

The red burning clays (P67-2, P80-1, P81-1, P81-2, P85-1, P92-1, P95-1, P105 1-2, P107-1, P108-1, and P111-1) have an average linear drying shrinkage of 23 percent and an average dry modulus of rupture value of 1020 pounds per square inch. The modulus of rupture values for the fired clays are erratic, due to cracked test pieces and are of no significance except as an example of an undesirable burning quality. These bond clays, although having possibilities as a bond for foundry moulding sand and as a bond in a sewer pipe body containing grog and high alumina clay, are of little economic importance in the county because of the abundant supply of more efficient bentonite for foundry bond use and the lack of suitable grog clays and high alumina clays for sewer pipe.

Samples P35 2-4, P42-2, P59 1-2, P63-1, P66-1, P66 2-3, and P71-1 are the buff burning bond clays. These clays are characterized by the high linear drying shrinkage and high dry strength. They cannot be used alone as a ceramic body because of their tendency to crack on burning. These clays are more aluminous than the red burning bond clays and could be most effectively used by blending with their sandy overburden to produce face brick, hollow tile, building block, drain tile, and common brick.

Samples P2 1-4 and P7 2-4 are of the buff burning variety but are stained with soluble salts and are less desirable.

Samples P53 1-3, P55-1, and P71-2 are stained with soluble salts and bloat or crack on burning to low temperatures. These clays are of little economic importance.

CERAMIC CLAYS—MISCELLANEOUS CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
P1	1	28.90	28.13	10.41	375	Yellow
P15	1–3	35.17	39.32	15.33	623	Dark gray
P26	1–3	38.40	41.42	16.32	449	Gray
P30	2	34.35	33.80	12.84	371	Yellow
P39	2	33.17	27.93	10.33	366	Gray
P46	1-2	36.80	36.97	14.27	526	Gray
P50	1	20.06	13.65	5.37	214	Light gray
P90	1–2	39.08	41.40	16.32	875	Medium gray
P99	1–2	33.73	33.43	12.67	835	Light gray

SCREEN ANALYSES

SAMPLE P1 1

Retained on screen	Percent	Character of residue
60	8.98	Abundance of limonitic argillaceous clay nodules; small amounts of hematite and quartz; trace of muscovite.
100	3.16	Abundance of limonitic clay nodules; considerable quantities of quartz and muscovite; trace of hematite.
250	5.44	Abundance of limonitic clay nodules; considerable quantities of quartz and muscovite.
Cloth	82.42	Clay substance including residue from above.

SAMPLE P50 1

Retained on screen	Percent	Character of residue
60	.55	Abundance of light-gray argillaceous clay nodules; considerable quantity of ferruginous material; small amounts of plant fragments and quartz.
100	.94	Abundance of white clay nodules; considerable quantity of quartz; small amounts of ferruginous nodules and muscovite.
250	7.03	Abundance of quartz; small amount of limonitic clay nodules.
Cloth	91.48	Clay substance including residue from above.

SAMPLE P90 1-2

Retained on screen	Percent	Character of residue
60	4.44	Abundance of micaceous, calcareous, glauconitic gray nodules; considerable quantity of fossil fragments; small amount of aragonite.
100	7.50	Abundance of micaceous, calcareous, glauconitic gray nodules; considerable quantity of fossil fragments; trace of muscovite.
250	13.35	Abundance of micaceous, calcareous, glauconitic gray nodules; considerable quantity of muscovite; small amount of fossil fragments.
Cloth	74.71	Clay substance including residue from above.

SAMPLE P99 1-2

Retained on screen	Percent	Character of residue
60	1.86	Abundance of glauconitic, calcareous nodules; considerable quantity of fossil fragments; trace of pyrite.
100	4.62	Abundance of glauconitic, calcareous nodules; considerable quantity of fossil.
250	9.48	Abundance of fossils; considerable quantity of glauconitic, calcareous nodules; small amount of muscovite.
Cloth	84.04	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSES

Sample P1 1

Ignition loss	5.88	Lime, CaO	0.17
Silica, SiO_2	65.68	Magnesia, MgO	0.39
Alumina, Al_2O_3	15.42	Manganese, MnO_2	0.11
Iron oxide, Fe_2O_3	10.19	Alkalies, (K_2O, Na_2O)	0.59
Titania, TiO_2	1.29		

Sample P50 1

Ignition loss	3.25	Lime, CaO	None
Silica, SiO_2	82.84	Magnesia, MgO	0.35
Alumina, Al_2O_3	10.01	Manganese, MnO_2	Trace
Iron oxide, Fe_2O_3	1.21	Alkalies, (K_2O, Na_2O)	0.67
Titania, TiO_2	1.22		

Sample P90 1-2

Ignition loss	22.95	Sulphur, SO_3	0.53
Silica, SiO_2	32.17	Magnesia, MgO	0.13
Alumina, Al_2O_3	12.32	Manganese, MnO_2	0.04
Iron oxide, Fe_2O_3	3.70	Alkalies, (K_2O, Na_2O)	0.61
Titania, TiO_2	0.55	Carbon dioxide,* CO_2	15.38
Lime, CaO	26.49		

Sample P99 1-2

Ignition loss	29.37	Magnesia, MgO	0.14
Silica, SiO_2	22.00	Manganese, MnO_2	Trace
Alumina, Al_2O_3	9.47	Alkalies, (K_2O, Na_2O)	0.89
Iron oxide, Fe_2O_3	2.60	Sulphur, SO_3	0.31
Titania, TiO_2	0.44	Carbon dioxide,* CO_2	23.23
Lime, CaO	34.51		

B. F. Mandlebaum, analyst

* Separate determination

PYRO-PHYSICAL PROPERTIES

Test Holes P1, P15, P26, P30, P39, P46, P50

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk Specific gravity	Apparent Specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
P1 1	02	35.53	16.92	1.84	2.69	4.47	1.52	1512	Red
	1	30.92	16.44	1.88	2.73	5.73	1.94	1220	Red
	3	29.88	15.74	1.90	2.70	6.16	2.11	1835	Red
	5	28.03	14.76	1.90	2.64	6.51	2.21	1641	Red
	7	27.20	14.49	1.91	2.64	6.68	2.29	1774	Red
	9	23.50	12.13	1.94	2.53	8.22	2.81	2220	Brown St. H.
P15 1-3	02	25.28	13.66	1.85	2.48	8.32	2.85	2990	Lt. chocolate* St. H.
	1	25.48	13.75	1.85	2.48	8.33	2.85	2797	Lt. chocolate*
	3	21.05	10.92	1.92	2.43	11.91	4.14	2285	Lt. chocolate*
	5	23.45	13.23	1.85	2.40	8.04	2.74	2799	Lt. chocolate*
	7	18.45	9.50	1.94	2.39	12.88	4.50	2092	Chocolate*
P26 1-3	02	32.13	18.49	1.74	2.56	5.40	1.83	1617	Lt. brown*
	1	32.72	18.54	1.77	2.62	7.07	2.42	1423	Lt. brown*
	3	29.82	16.51	1.78	2.54	8.02	2.74	1401	Lt. chocolate* St. H.
	5	29.58	16.91	1.81	2.61	5.85	1.95	1449	Lt. chocolate*
	7	27.08	15.03	1.76	2.40	8.80	3.02	1610	Chocolate*
P30 2	02	29.80	14.94	1.94	2.76	13.56	4.76	1027	Red St. H.
	1	29.77	15.05	1.97	2.81	14.96	5.27	1631	Red
	3	26.73	13.21	2.02	2.76	15.96	5.65	1697	Red
	5	25.52	12.79	2.01	2.70	15.57	5.50	2075	Red
	7	24.50	12.00	2.05	2.70	16.63	5.87	2162	Dk. red
P39 2	02	35.85	22.25	1.61	2.52	8.99	3.09	1024	Salmon red
	1	36.67	22.65	1.62	2.58	8.99	3.09	1579	Salmon red
	3	31.40	18.50	1.76	2.45	12.24	4.24	1732	Salmon red
	5	31.75	19.12	1.68	2.46	12.00	4.17	2072	Salmon red
	7	27.95	15.75	2.78	2.47	16.80	5.95	2627	Salmon red St. H.
	9	22.40	13.40	1.72	2.15	13.08	4.57	1692	Brown Bl.
P46 1-2	02	25.35	13.96	1.82	2.44	11.07	3.49	2507	Lt. chocolate* St. H.
	1	26.07	13.91	1.87	2.53	13.70	4.79	2460	Lt. chocolate*
	3	23.30	12.00	1.90	2.47	15.30	5.31	1550	Lt. chocolate* Cr.
	5	22.55	12.36	1.82	2.38	10.86	3.77	1765	Lt. chocolate* Cr.
	7	20.70	10.86	1.91	2.43	15.60	5.40	3007	Chocolate*
P50 1	02	28.68	15.89	1.80	2.54	−1.60	−0.54	551	Lt. buff
	1	29.72	16.52	1.80	2.55	−1.59	−0.54	510	Lt. buff
	3	28.93	16.07	1.80	2.53	−1.73	−0.57	1375	Lt. buff
	5	28.90	16.00	1.79	2.52	−1.47	−0.50	736	Lt. buff
	7	29.07	16.02	1.81	2.55	−1.28	−0.44	716	Lt. buff
	9	27.37	15.03	1.82	2.50	−0.61	−0.20	1117	Lt. buff
	11	28.35	15.73	1.80	2.51	−1.71	−0.57	1637	Lt. buff Not St. H.

TEST HOLES P90, P99

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
P90 1-2	02	40.57	27.53	1.47	2.48	4.66	1.59	2129	Grayish cream
	1	39.50	26.05	1.52	2.51	11.82	4.10	2047	Grayish cream
	3	42.07	27.60	1.52	2.63	11.90	4.14	2372	Grayish cream
	5	42.75	28.33	1.49	2.66	11.49	3.99	1722	Grayish cream
	7	....	....	......	......	....	......	....	Yellowish Green Gl. St. H.
P99 1-2	02	46.50	35.88	1.30	2.43	2.40	0.81	1255	Grayish cream
	1	44.95	33.90	1.34	2.41	3.07	1.04	1293	Grayish cream
	3	45.63	35.43	1.32	2.47	3.08	1.04	1253	Grayish cream
	5	50.00	35.17	1.45	2.93	11.80	4.10	1277	Grayish cream
	7	42.10	27.93	1.48	2.57	14.60	5.12	1582	Grayish cream
	9	33.33	18.93	1.78	2.56	29.10	10.83	N.D.	Grayish cream Not St. H.

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

* Stained with calcium salts

POSSIBILITIES FOR UTILIZATION

Four varieties of materials are represented by the Miscellaneous Clays. Samples P15 1-3, P26 1-3, and P46 1-2 burn to light chocolate brown colors but are stained with a white scum which is probably calcium sulphate. The staining does not alter the ceramic properties of the clays but would make them undesirable for face brick and other similar building materials that are exposed to view. The three clays have good plastic, drying, and burning properties and are suitable for making common brick, partition tile, and drain tile.

Samples P1 1, P30 2, and P39 2 are similar to the preceding group of clays as to their ceramic properties with the exception that they burn to clear shades of red and reddish brown and are not stained with soluble salts. These clays are suitable for making red-burning face brick, partition tile, building block, common brick, and drain tile.

Sample P50 1 is a cream to buff burning silt containing just enough clay to make the material plastic. The material on burning is very open bodied and structurally weak. The alteration in porosity and absorption on burning from cone 02 through cone 11 is very slight. The material has a fairly uniform burning expansion rather than the usual shrinkage. Due to the low burned strengths, the clayey silt is not suitable for structural clay products when used alone but may be blended with more plastic clays to reduce shrinkage. In this respect it would be suitable for making a variety of heavy clay products.

Samples P90 1-2 and P99 1-2 contain 26.49 percent and 34.51 percent lime (CaO) respectively. These two materials are not suited for ceramic products, due to their high lime contents. They were tested as a clay before their lime content was known, and their possibilities as a limy material are discussed under the heading of Argillaceous Limestones.

BENTONITE

CHEMICAL ANALYSES* — SCREEN ANALYSES

Sample	Ign. loss	Silica SiO_2	Alumina Al_2O_3	Iron Fe_2O_3	Titania TiO_2	Lime CaO	Magnesia MgO	Alkalies K_2O+Na_2O	Character of residue in order of abundance	Percent retained on 325-mesh screen
P36 -1	9.13	58.00	24.02	4.79	0.74	0.72	1.78	0.30	Non slaking white clay, quartz, and limonite	6.27
P37 -1	8.86	58.52	23.87	4.51	0.93	0.48	1.24	0.37	Quartz, limonite, and non slaking white clay.	4.67
B75 -1	763	63.68	22.60	3,09	0.69	0.15	1.39	0.33	Quartz, non slaking white clay, glauconite, limonite, and mica.	34.51
F81 -1	12.89	58.41	21.55	3.00	0.74	0.53	1.86	0.43	Quartz, glauconite, non slaking white clay, and limonite.	21.31
B99 -1	11.85	55.44	23.11	4.83	0.64	0.81	2.19	0.34	Non slaking white clay, and limonite.	3.70
P113-1	9.16	58.64	21.55	4.40	0.59	1.30	1.90	0.31	Non slaking white clay, quartz, glauconite, & mica	29.24
P114-1	8.96	58.97	20.79	5.30	0.74	1.49	3.55	0.36	Non slaking white clay, quartz, limonite, & glauconite.	27.62
P123-1	8.40	62.18	20.70	4.21	0.89	0.67	2.29	0.42	Chert, quartz, & limonite	8.95
P143-1	8.87	59.99	20.45	5.81	0.41	0.30	4.19	0.42	Quartz, limonite, and non slaking white clay.	7.28
P144-1	11.28	60.13	20.06	4.95	0.32	0.56	2.29	0.38	Non slaking white clay, mica, quartz, & limonite	11.40
P146-1	8.76	58.94	22.52	5.25	0.62	0.73	3.31	0.58	Limonite, quartz and non slaking white clay.	5.15

B. F. Mandlebaum, analyst
* All samples ground to pass 100-mesh screen
All samples dried at 100°C

DISCUSSION OF DATA

Chemical analyses alone do not serve as an index to quality when evaluating bentonites. Bentonites which are free of contamination and accessory minerals show considerable variation in their chemical composition. The bentonites tested for this report contain a wide assortment of mineral aggregates in variable quantities. It could not be determined in the laboratory just which kind or how much of the accessory minerals that were collected by wet screen analyses were inherent to the samples or which may have been present by contamination.

Screen analyses indicate the amount and kind of residue retained on the 325-mesh screen after high-speed blunging in the presence of sodium pyro-phosphate. Two treatments of 20 minutes each were given each sample. The residue was washed after each blunging and screening. Inasmuch as the many uses of bentonites are directly related to their fine-grained particle size and colloidal content, the coarse-grained constituent, such as that retained on the 325-mesh screen, must be considered as an impurity even though it may be essentially clay.

Sample B99-1 has the lowest total silica content and the least residue on the 325-mesh screen. Most of the screen residue is a non slaking white clay and would not be as detrimental as quartz or other gritty material. This sample is probably the best of those tested.

Sample P36-1, P37-1, and P146-1 rank next in low total silica and low screen residue. Non slaking white clay, quartz and limonite make up the screen residue.

Samples B75-1, F81-1, P113-1, and P114-1 contain fresh glauconite grains and represent unweathered bentonite. The screen residue for these samples ranges from 21.31 percent to 34.51 percent. Most of the residue is clay and quartz. If the quartz content of these samples is inherent to the material, the bentonites must be considered as being of inferior quality.

Samples P123-1, P143-1 and P144-1 have high total silica contents and screen residues ranging from 7.28 percent to 11.40 percent. These samples are of medium grade when compared to the others tested.

ARGILLACEOUS LIMESTONE

CHEMICAL ANALYSES

Sample No.	Ignition loss	Carbon dioxide	Calcium carbonate, calculated from carbon dioxide
P88 1-2	27.19	19.25	43.78
P90 1-2*	22.95	15.38	34.98
P92 2	17.16	10.25	23.31
P95 3	15.12	8.93	20.31
P99 1-2*	29.37	23.23	52.85
P105-4	12.98	7.16	16.28

*Complete chemical analyses under "Miscellaneous Clays"

DISCUSSION OF DATA

Seventeen samples of "limy material" were tested for their carbon dioxide content. Nine of the samples were found to contain no carbon dioxide and two additional samples to contain less than 1 percent. The remaining six samples contained CO_2 in amounts ranging from 7.16 percent to 23.23 percent. Of these, only samples P88 1-2 and P99 1-2 contain enough lime to be of economic interest.

Samples P88 1-2 and P99 1-2 have limited possibilities as a rock wool material. They contain too much alumina and too little lime to be used as wool rock, but, due to their plastic nature, they could be blended with silica sand to reduce their alumina content and with high grade limestone to increase their lime content and then formed into "brick" for utilization as wool rock. The procedure is of doubtful commercial value but is probably the only way to utilize these materials.

LABORATORY PROCEDURE

PREPARATION

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

FORMING OF TEST PIECES

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

PLASTIC, DRY, AND WORKING PROPERTIES

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

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

FIRED PROPERTIES

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

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

SCREEN ANALYSES

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

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

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

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

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

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

CHEMICAL ANALYSES

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

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

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

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

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

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

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

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

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

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

Carbon Dioxides: Carbon dioxide was determined by use of a Schroedter alkalimeter, using dilute hydrochloric acid to evolve the CO_2 and concentrated sulphuric acid to trap any moisture evolved.

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

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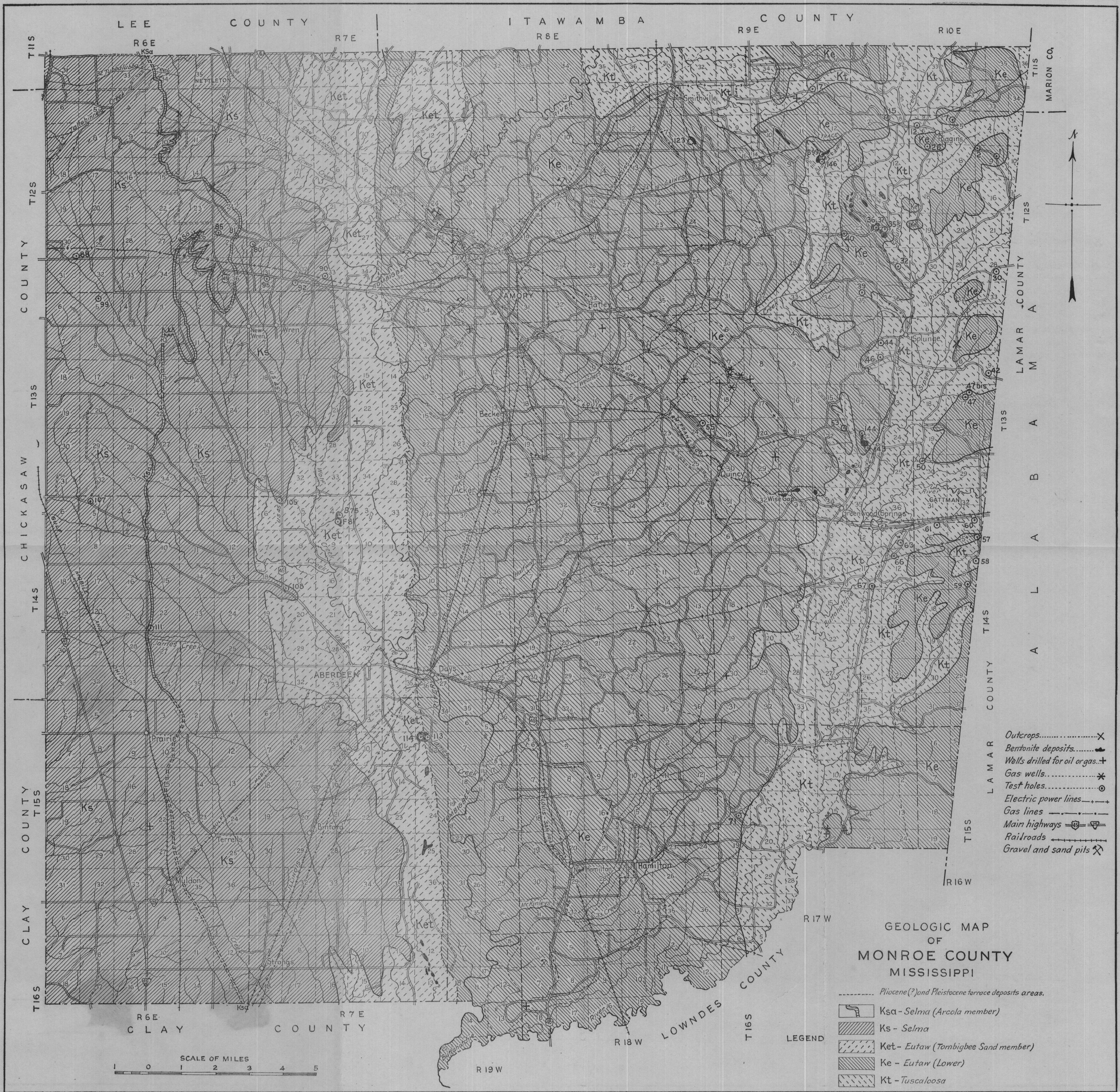
GEOLOGIC MAP
OF
MONROE COUNTY
MISSISSIPPI
LEGEND
Pliocene(?) and Pleistocene terrace deposits areas.
Ksa - Selma (Arcola member)
Ks - Selma
Ket - Eutaw (Tombigbee Sand member)
Ke - Eutaw (Lower)
Kt - Tuscaloosa
Outcrops
Bentonite deposits
Wells drilled for oil or gas
Gas wells
Test holes
Electric power lines
Gas lines
Main highways
Railroads
Gravel and sand pits
SCALE OF MILES
1 0 1 2 3 4 5
LEE COUNTY
ITAWAMBA COUNTY
MARION CO.
LAMAR COUNTY
ALABAMA
CHICKASAW COUNTY
CLAY COUNTY
LOWNDES COUNTY
R6E
R7E
R8E
R9E
R10E
R16W
R17W
R18W
R19W
T11S
T12S
T13S
T14S
T15S
T16S
AMORY
ABERDEEN
Smithville
Nettleton
Hatley
Becker
Quincy
Wise Gap
Greenwood Springs
Gattman
Splunge
Hamilton
Muldon
Prairie
Binford
Strongs
Terrells
Wren
Days
Acker