MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph. D.
Director

BULLETIN 45

UNION COUNTY MINERAL RESOURCES

GEOLOGY
By
LOUIS COWLES CONANT, Ph. D.

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

UNIVERSITY, MISSISSIPPI
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Prepared in cooperation with the Union County citizens and
the WPA as a report on O.P.465-62-3-275.

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MISSISSIPPI GEOLOGICAL SURVEY

LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi
February 25, 1942

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

Gentlemen:

Herewith is Bulletin 45, Union County Mineral Resources—Geology by Louis Cowles Conant, Ph.D.; Tests by Thomas Edwin McCutcheon, B.S., Cer. Engr.—which is published as a fulfillment in part of the sponsorship pledge of the Mississippi State Geological Survey, necessary to obtain Federal-WPA funds for the various county geologic mineral surveys of the State. Like all other county reports, it would not have been possible without the splendid cooperation of the Union County officials, civic organizations, and citizens in general—all of whom acted as cosponsors to the State Geological Survey.

As usual the first part of the Geologic section is devoted to the sequence of the geologic formations and the second part, to economic geology, especially the clays; and the Test section is devoted almost exclusively to the clays.

"Chemical analyses show that a great number of clays contain alumina (Al_2O_3) in excess of that common to kaolin or the mineral kaolinite." These kaolinitic-bauxitic clays, "the high alumina clays of Union County, rank next to bauxite and bentonite in value per ton" (McCutcheon).

Although various Federal, State, and Commercial agencies are searching for a method of reducing these clays to alumina (Al_2O_3) on a commercial basis, the War Production Board advises on February 3 and 6, 1942, that no such process has been perfected. The various recent and present field investigations by Federal agencies that parallel the survey covered in this report may reveal some additional tonnage or additional areas.

Very sincerely and respectfully,

William Clifford Morse,
State Geologist and Director

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GEOLOGY

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INTRODUCTION

The field work on which this report is based was conducted from October, 1938, to July, 1939, under the joint auspices of the Federal Works Projects Administration and the Mississippi Geological Survey as one unit in a state-wide study of the mineral resources of Mississippi, and was of two types: (1) prospecting of clays and other minerals chiefly by auger holes and test pits, and (2) geologic study and mapping of the entire county.

The mineral samples were tested in the laboratory of the Mississippi Geological Survey and the report of the ceramic engineer constitutes the second part of this report; the general geology is described in this, the first part, of the report and is accompanied by a geologic map of the county (Pl. 1). On this map the contacts were located in most instances by reference to such easily recognized features as road intersections and stream crossings. Information for the map was obtained not only from outcrops, but from auger holes, soil colors, the presence of springs, and by projection of known contacts taking into consideration the topography and the presumed dip of the strata. All elevations were determined with an altimeter. Most of the contact lines are probably accurate well within a quarter of a mile, the most likely exceptions being the boundaries of the subdivision of the Ripley formation, and the southern 3 miles of the Clayton-Porters Creek contact where the relief is low and exposures are scarce. When much-needed topographic maps are available, a more accurate geologic map can be drawn.

GEOGRAPHY

Union County, in north Mississippi (Fig. 1), contains 415 square miles and had a 1940 population of 21,867, of which 4,282 are colored. New Albany, the county seat, has a population of 3,602. Other incorporated communities and their populations are: Sherman 449 (of which 48 are in Union County), Myrtle 349, Ingomar 262, and Blue Springs 183.

The Gulf, Mobile & Ohio Railroad runs approximately north and south near the middle of the county, and the St. Louis-San Francisco (Frisco) Railway crosses the county in a general northwest-southeast direction.

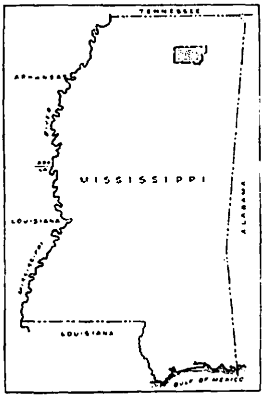

Figure 1.—Map showing the location of Union County.

Three main highways cross the county: (1) U. S. 78, a concrete highway, follows closely the Frisco Railway line; (2) Mississippi 15, a black-top highway, follows approximately the line of the Gulf, Mobile & Ohio Railroad; and (3) Mississippi 30, a gravelled highway, crosses the county in an essentially east-west direction. Most of the other roads in the county have been sufficiently gravelled to permit all-weather travel. In the hill sections, notably the regions underlain by the McNairy and Wilcox sands, and the ridges north and east of New Albany, most of the roads follow ridges.

The two railroads and three highways all intersect at New Albany.

Except for New Albany, the county is distinctly rural, the small communities centering chiefly about one or more stores and churches, a school, and, where near the railroads, a cotton gin. Lumbering has decreased in importance with the cutting of the forests, and in recent years the Federal government has bought up considerable land in the western part of the county for incorporation in the Holly Springs National Forest.

Agriculture is the chief means of support, but much of this has been carelessly conducted by tenant farmers, resulting in much worn out soil and badly gullied areas.

Cotton, the chief crop, is raised for the cash income it affords, though in recent years enforced cotton acreage reduction and the encouragement of diversification by various agencies have resulted in a somewhat greater variety of farm products.

New Albany, a progressive and flourishing small city, is the trading center for most of Union County. In addition to various retail and wholesale distributors, banks, hotels and restaurants, the city has a bottling plant, broom factory, cheese plant, and large garment factory. In years past there were two brick plants at New Albany, but both of these have succumbed to various difficulties and nothing is left of them.

A plentiful supply of unskilled labor, both white and colored, is available for any industry likely to require it.

Most of the county is served by TVA power lines.

TOPOGRAPHY

Four well-defined north-south topographic belts cross the county. These are the Black Prairie, the Pontotoc Hills, the Flatwoods, and the North Central Hills (Fig. 2).

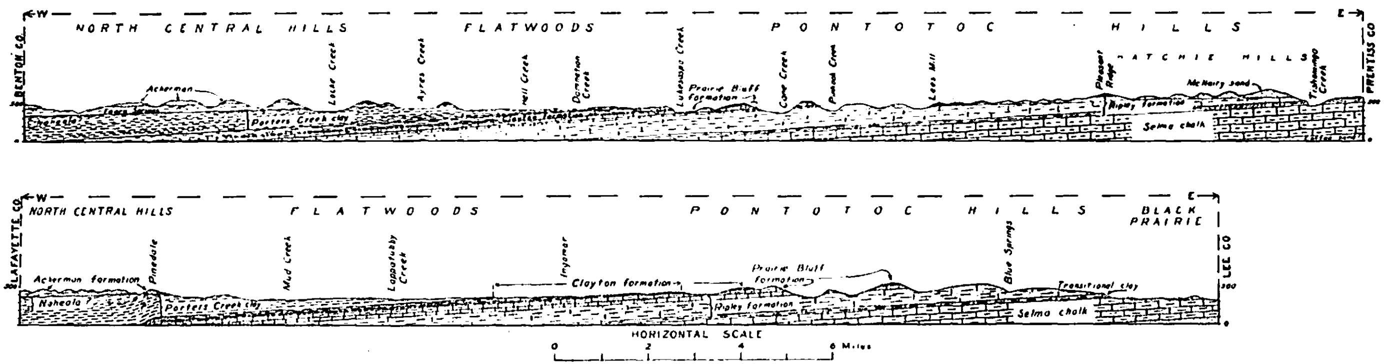

Figure 2.—Generalized east-west cross sections of Union County showing the presumed arrangement of the strata below the surface. The upper section is near the northern edge of the county, the lower section near the southern edge. The surface relief and the dips are exaggerated about ten times, and the relief is much generalized.

BLACK PRAIRIE

The Black Prairie, in its larger aspect, is a fertile lowland belt many miles wide which crosses Georgia and Alabama, curves gracefully across northeastern Mississippi, and extends on to the north into Tennessee. Its presence is due to the underlying Selma chalk which has yielded to solution and other erosional agencies more readily than have the adjacent materials. Its western edge lies just within the eastern part of Union County at elevations of about 375 feet. Approximately 40 or 50 square miles of the county are included in it. In Union County the westernmost part of this belt is underlain by the transitional clay of the lower Ripley formation, and rises gradually some 50 or 75 feet, forming an intermediate low rolling area, some half a mile to 3 miles wide, between the Prairie proper and the Pontotoc Hills to the west.

PONTOTOC HILLS

The Pontotoc Hills, an irregular hilly region, occupies approximately two-thirds of Union County. Many previous writers have termed it the Pontotoc Ridge, while various local names have been assigned to parts of it, but since it is an irregular feature, and by no means a simple ridge, the term here used seems preferable. These hills reflect the presence of various underlying strata which, as a group, are more resistant to erosion than the materials on either side. Some 50 miles south of Union County the hills die out, but to the north they extend as an increasingly prominent feature through Tippah and Alcorn Counties into Tennessee.

In Union County several distinctly different regions constitute this belt. Its easternmost portion, adjoining the Black Prairie, is underlain by sands, marls, and clays of the lower and middle portions of the Ripley formation; consequently, it is a region of irregular hills which rise noticeably above the low rolling hills at the west edge of the Prairie but in turn are dwarfed by the much higher hills farther west. Within this area a southern extension of the McNairy sand tongue into the northeastern part of the county is responsible for a rugged topography which is the highest in Union County, many of the summits having elevations from 600 feet to nearly 800 feet. In reality, this region is a southern extension of the Hatchie Hills of Tippah County.

West of this irregular area stands the most spectacular part of the Pontotoc Hills in Union County, hills which reflect the presence of resistant limestone, sandstone, and chalk layers of the upper

Ripley, Prairie Bluff, and lower Clayton. The highest of these hills is probably Grubbs Mountain, some 2 miles east of Center School and about 600 feet above sea level. In this region a steep east-facing escarpment is quite impassable by roads except in particularly favorable places. Although streams have dissected this crest irregularly, as can be seen by an inspection of the geologic map (Pl. I), the hilltops, in general, slope gently westward about 30 feet to the mile to the Flatwoods—a slope corresponding roughly to the dip of the underlying starta. Noteworthy instances of this westward slope are the two 5-mile ridges east of New Albany, one of which is between the Tallahatchie and King Creek, the other between King Creek and Camp Branch. This dip slope is also easily seen from Highway 15 about 3 miles south of New Albany where the land between Wallerville and Ingomar has an almost unbroken slope which merges imperceptibly with the Flatwoods just west of Ingomar at an elevation of about 375 feet.

FLATWOODS

West of the Pontotoc Hills is a conspicuously flat area (Fig. 2) which has been called the Flatwoods since 1860[1] or perhaps earlier. Its elevations in Union County typically range from about 300 feet above sea level, near Rocky Ford, to about 400 feet. It is underlain by Porters Creek clay, often referred to locally, though incorrectly as "soapstone." The clay offers little resistance to erosion, and yields a heavy cold stiff soil which is difficult to cultivate. Ungravelled roads in this region are virtually impassable in wet weather, a fact eloquently suggested by the names of two streams, Hell and Damnation Creeks. There are relatively few hills, and most of those which are present owe their existence to a capping of red Wilcox sand, so located between drainages as to have escaped complete erosion.

The Flatwoods belt is some 4 to 8 miles wide except in the valley of the Tallahatchie where its much greater width causes it to extend beyond the bounds of Union County into Marshall and Lafayette Counties.

NORTH CENTRAL HILLS

The western few miles of Union County, excepting the Tallahatchie valley, lie in the broad north-south belt of the North Central Hills which extends as far westward as the Mississippi River lowland. This region is underlain by Wilcox sands and clays which have been irregularly eroded yielding a rugged topography of about 200 feet relief (Fig. 2). In recent years deforestation and careless farming have contributed to serious gullying and erosion, making this area one of the worst, in that respect, in the entire United States.

DRAINAGE AND WATER RESOURCES

The Tallahatchie and its tributaries drain about 80 percent of Union County westward into the Mississippi River; the headwaters of the Hatchie drain about twelve square miles of the northeastern part of the county northward to Tennessee then west to the Mississippi River; and various tributaries of the Tombigbee River drain the southeastern part of the county directly to the Gulf of Mexico.

Most of the streams, except in their uppermost portions, are well graded and flow over broad alluvial bottoms, or floodplains. It is probable that in the early days of the white man's occupation the streams were clearer and flowed somewhat more actively over smaller floodplains, so that at several places grain was ground by water power. Today all these old mills have vanished and one wonders, on visiting their sites, where the water power was obtained. It seems probable that with the cutting of the forest and the tilling of the soil much more sand and silt were washed down the slopes than the main streams could handle. Consequently the valleys were choked with debris, the bottom lands were made larger and higher, and the rapids were eradicated. In recent years most of the large streams and many of the smaller ones have been artificially channeled to facilitate more rapid run-off and minimize the danger of flooded bottoms after heavy rains. In the extreme eastern part of the county some of the streams, like Tishomingo and Dry Creeks, flow in natural channels in the Selma chalk, are relatively free from mud, and have not had to be channelled.

As the water in most of the streams is too muddy for domestic or industrial uses, water for such purposes is obtained from small springs, shallow wells, and artesian wells, the last named being the most reliable. Most of the artesian wells in the county are between 30 and 500 feet deep[2]. New Albany obtains its water from two wells about 1000 feet deep. Many of the wells in the valleys flow with a slight pressure. Union County affords interesting examples of true artesian wells only about 30 feet deep, in the valley of King Creek, about 3 miles south of New Albany[3].

GENERAL GEOLOGY

Rocks formed during the three earliest eras of geologic time, the Archeozoic, Proterozoic, and Paleozoic, are not present at the surface in Union County. The oldest deposits in the county date from the Cretaceous, or the last period of the Mesozoic era; the youngest, from the Eocene period of the Cenozoic era. Coastal plain deposits of these ages, consisting of impure chalk, unconsolidated sands, marls, and clays, and subordinate layers of limestone and sandstone underlie the county. The contact between the Prairie Bluff and Clayton formations is the boundary between the Mesozoic and Cenozoic groups.

During late Mesozoic and early Cenozoic times, the shore line of the Gulf of Mexico was far inland form the present coast line. Accordingly sediments of those ages are present over much of Georgia and Alabama and all of Mississippi except a small part of Tishomingo County, and extend northward on both sides of the Mississippi River as far as Cairo, Illinois, and cover considerable portions of Missouri, Arkansas and Texas, and all of Louisiana.

This extinct northern arm of the Gulf of Mexico is now referred to as the Mississippi embayment. Streams flowing into this embayment deposited great quantities of sand, silt, and clay, the differences in the materials being due in large part to changing conditions in the drainage areas. Whenever the streams brought little debris to a region, calcareous precipitates and the shells of dead animals made up the bulk of the sea floor detritus, forming limestone, chalk, and marl. Inasmuch as the sea floor was repeatedly sinking, materials originally deposited in shallow water were covered by younger sands and muds until deposits several thousand feet thick were formed. The sinking, however, was not continuous, but was interrupted by halts and by minor uplifts at which times the sea water drained off and the sediments were exposed to erosion.

At times the waters of the embayment teemed with life, as is shown by the abundance of marine fossils at many places in the area. Since the forms of animal life are continually changing, with the disappearance of some species and the appearance of others, the presence of certain fossils in a sediment is to a geologist the most reliable indication of its geologic age. For example, sediments which contain shells of the large-ribbed spiral-beaked oyster, *Exogyra costata,* found throughout most of eastern Union County, are known from this fact to be of Cretaceous age. Also, the great differences between the kinds of fossils of the Cretaceous period and the ones of the next younger period indicate the intervention of a long period of time during which the area was out of water.

Large areas appear to have stood, at times, only slightly above sea level, and to have been flooded by rivers which spread silt and sand over them. Such deposits contain no marine fossils, but do contain scattered leaf and petrified wood fragments.

Partly because of the greater down-warping of the center of the embayment and partly because of the original slope which the deposits assumed, the strata have a gentle inclination or regional dip to the west of 15 to 30 feet to the mile (Fig. 2). The total thickness of the strata exposed in Union County is probably 900 to 1000 feet.

The accompanying generalized section, arranged with the youngest materials at the top, shows the formations present at the surface in Union County, together with their geologic ages.

Generalized Section of Exposed Formations in Union County

Group	System and (Series)	Formation	Member	Character	Max. Thickness
Cenozoic	Recent or Pleistocene	Colluvium		Sandy and silty material; reworked by rainwash, soil creep, landslips, etc.	10
	Pleistocene or Pliocene	Alluvium		Sand, silt, and clay deposited by present streams in their valleys; older deposits now partly removed form terraces.	10
		Unconformity			
	Eocene (Wilcox)	Ackerman formation	Clay member	Laminated gray carbonaceous silty clays; not known in Union County.	
			Basal sand member	Red or white sand, commonly cross-bedded; some clay-ball breccia; locally consolidated near base; petrified wood fragments; a few boulders near base.	100
		Unconformity			
		Fearn Springs formation		Fine or coarse basal sand; gray and lignitic clays, commonly silty; cross-bedded laminated micaceous clay with sand laminae.	115
		Unconformity			
	Paleocene (Midway)	Porters Creek clay	Bauxite-kaolin zone	Kaolin and bauxite found locally; weathered products of underlying Porters Creek clay, into which they grade.	30
			Upper phase	Laminated dark-gray or black silty clay with laminae of silt or sand; commonly highly micaceous; scattered siderite concretions; probable equivalent of the Naheola formation of Alabama.	300?
			Middle phase	Dark-gray or black montmorillonitic clay; lamination nearly absent; conchoidal fracture; at least 2 thin indurated layers of glauconitic siltstone near base.	100±
			Basal phase	Dark-green or black montmorillonitic clay, glauconitic, slightly bentonitic; locally has a thin indurated glauconitic siltstone layer at base.	50±
		Clayton formation	Upper member	Dark laminated clays, marls, and sands; glauconitic throughout; shell and plant remains locally abundant; 1-foot limestone layer probably present in lower portion.	60
			Basal member	Highly fossiliferous glauconitic sandy limestone and marl layers, limestone predominating.	15
		Unconformity			
Mesozoic	Cretaceous (Gulf)	Prairie Bluff chalk		Fossiliferous blue-black and dark-gray impure chalk, merging northward and upward into the sandier Owl Creek formation which is present only locally in Union County.	45
		Unconformity			
		Ripley formation	Upper phase	Limestone, marl, and subordinate sand and sandstone layers; limestone highly fossiliferous, other strata locally so.	150±
			McNairy sand tongue	Cross-bedded micaceous marine sand, commonly ferruginous; locally indurated.	100±
			Lower phase	Blue-black impure marls, dark laminated clays, many laminae and scattered beds of yellow sand; marls locally highly fossiliferous; where overlain by McNairy sand is considered the Coon Creek member.	200
			Transitional clay	Highly calcareous gray sandy clay, somewhat fossiliferous; distinguished from Selma chalk by its sandy impurity.	50
		Selma chalk		Consolidated impure chalk, locally highly fossiliferous; farther south in Mississippi may be 1,000 feet thick.	300±

STRATIGRAPHY—MESOZOIC GROUP

CRETACEOUS SYSTEM

The Upper Cretaceous series as exposed in Mississippi consists of seven recognized formations: the Tuscaloosa, Eutaw, Coffee, Selma, Ripley, Prairie Bluff, and Owl Creek. Only the Selma, Ripley, and Prairie Bluff are recognized in Union County, though some material mapped as Prairie Bluff is probably Owl Creek.

SELMA CHALK

The Selma chalk, named for the town of Selma, Alabama, is a hard impure chalk several hundred feet thick, which underlies the Black Prairie. Near the surface, weathering has dissolved the calcium carbonate which makes up most of the rock, and the clayey impurities in it have remained as a mantle of fertile dark-gray clay. Farther south in Mississippi the formation is on the order of 1000 feet thick, but its exposures thin to the north and disappear entirely a few miles north of the Tennessee-Mississippi line. In the latitude of Union County its thickness is considerably less than 1000 feet, and only about 50 feet of that is exposed in Union County.

In many places in the Prairie, gentle hill slopes expose large areas of the chalk with little or no soil above it, though such bald spots are more typically developed east of Union County. Notable examples of this are on the long north-south "Birmingham Ridge", a fraction of a mile east of the Union-Lee County line northeast of Sherman, and on U. S. Highway 78 a few miles southeast of Sherman. Within Union County such barren areas, fortunately, are uncommon. Good exposures of the chalk, however, are present in Union County: (1) in the bed of Dry Creek from Highway 30 south to the county line, (2) at the base of Red Hill 3 miles north of Sherman (E. edge, Sec.12, T.8 S., R.4 E.), and (3) in the bed of a creek about 1 mile west of Sherman at the crossing of U. S. Highway 78.

Locally the chalk abounds in fossil oyster shells, especially those belonging to the genera *Exogyra* and *Gryphaea*. Although not numerous in Union County, one such fossiliferous exposure is present at the previously mentioned Red Hill locality.

In its upper portions the chalk contains more clayey impurities, being much less compact. Good exposures of this phase may be seen in the lower half of Kennedys bluff on Tishomingo Creek, a quarter of a mile north of Highway 30 (Sec.14, T.6 S., R.5 E.), whereas continuous outcrops in the bed of Dry Creek show the transition from the more impure material near Highway 30 to the chalkier material 2 miles farther south.

The gradational character of the material makes it difficult to map a contact between the Selma and Ripley formations, but Monroe has suggested[4] that the contact be considered that horizon above which sandy impurities become noticeable, and the map has been drawn on that basis. In many places on the map the location of this contact is open to some doubt.

RIPLEY FORMATION

GENERAL FEATURES

The Ripley formation is the most widespread unit of the Gulf series, extending under various names from Texas and Arkansas to southern Illinois, thence through Kentucky, Tennessee, Mississippi, Alabama, and Georgia, and northward east of the Appalachian Mountains as far as New Jersey. It was named in 1860 for the town of Ripley, Mississippi, by Hilgard[5], who, included in the formation beds since designated as the Clayton limestone and the Prairie Bluff and Owl Creek formations.

In Union County the Ripley formation is about 300 feet thick. Good exposures of considerable thickness of the formation are uncommon, but many exposures of small sections of it enable one to obtain a fairly good idea of the formation as a whole.

Three distinct phases of the Ripley formations have been mapped in Union County. These are: (1) a basal transitional sandy, calcareous gray clay, (2) the main Ripley formation consisting chiefly of sandy clays, sands, marls, and limestones, and within which is (3) a tongue of McNairy sand which is recognized only in the northeastern part of the county.

TRANSITIONAL GRAY CLAY

So gradual is the transition from the Selma chalk to the Ripley formation that the exact location of the contact is largely a matter of personal opinion. As here divided, however, approximately the lower 50 feet of the Ripley formation consists of a sandy, highly calcareous gray marine clay which closely resembles the impure upper Selma chalk in appearance, in both fresh and weathered forms. In the unweathered condition it is commonly compact, fossiliferous, and massive, having a bluish-gray color, but when weathered it becomes a mass of heavy sticky gray clay which yields a red soil.

Ungravelled roads in this material are virtually impassable in wet weather.

One of the best exposures of the material is 3 miles north of Sherman (Center, Sec. 12, T.8 S., R.4 E.) where a secondary road traverses a steep east-facing slope, known locally as Red Hill. A number of auger holes in this region penetrated 9 to 23 feet of the heavy weathered material, below which they encountered more compact fresh material that was difficult to cut. At the base of the hill an outcrop of more compact and highly fossiliferous material is taken to be impure Selma chalk. A 45-foot exposure of the weathered gray clay, on a county line road 1 mile west of Sherman, is believed to represent nearly the full thickness of the transitional clay member. The contact between the clay and the overlying sandy marls and sands is well exposed near the top of the first steep rise in the road.

Highway 30, in its easternmost 3 miles in Union County, traverses a low hilly country which affords a series of exposures of the upper Selma, the transitional clay, and the overlying marls and sands of the lower Ripley.

Kennedys bluff on the west side of Tishomingo Creek a quarter of a mile north of Highway 30, first referred to by Hilgard[6], affords a 40-foot to 50-foot exposure of unweathered fossiliferous blue-black material which shows the gradation from the impure upper Selma to the transitional clay. Careful examination of this bluff reveals the fact that the upper half contains a noticeable sand impurity which is not present in the lower half.

MAIN RIPLEY FORMATION

It is customary to consider that part of the Ripley formation below the McNairy sand tongue, farther north in Mississippi, as the Coon Creek member[7,8] of the formation, and the material above the McNairy as an unnamed marine member of it[9]. Such division of the Ripley in Union County, however, can obviously be made only in the northeastern part of the county where the dividing McNairy is present. South of there recognition of the separate members is much more difficult, although they probably persist in recognizable form. Because of their lithologic gradation, however, it might be necessary to differentiate these subdivisions largely by their fossil content, and even then, a southern equivalent of the McNairy would probably further complicate the task. Separate mapping of these units was not attempted in the present study.

The lower part of the main Ripley, which in part is considered the Coon Creek member, consists chiefly of blue-black marls, thinly laminated dark clays, thin beds of yellow sand which are locally a few feet thick, and scattered thin sandstone layers. Locally the marl layers abound in well preserved fossils. A typical section of this material is exposed beside Highway 30 for a few hundred feet east of the road intersection 3 miles east of Pleasant Ridge (NE. Cor., Sec.20, T.6 S., R.5 E.).

SECTION ALONG HIGHWAY 30 JUST EAST OF ROAD INTERSECTION 3 MILES EAST OF PLEASANT RIDGE

	Feet	Feet
Lower Ripley formation		36
Sand, yellowish, extending to the top of hill	7	
Marl, blue micaceous, poor in fossils	6	
Sand, light-yellow, a few clay seams; lower 2 feet transitional to underlying member	12	
Marl, blue micaceous unfossiliferous	5	
Marl, blue micaceous fossiliferous; lower boundary concealed; at least	6	

Four tenths mile to the east (Sec.21), about 15 feet lower, the road cut at the top of a small hill shows 10 feet of clayey silt containing many *Ostreas* and other fossils. About a third of a mile farther east (road corner north of center Sec. 21) a cut at the top of the hill exposes about 10 feet of clayey silt containing *Ostreas,* underlain by a 3-foot exposure of blue marl rich in small pelecypods. A few hundred feet east of here, the transitional gray clay is exposed in the valley. A quarter of a mile farther east, the road cuts on the east wall of the valley (near road corner, W. edge, Sec. 22) expose the transitional gray clay 25 feet below weathered marl. The concealed zone is probably composed of laminae of sand, blue clay, and marl.

A marl layer extremely rich in fossils[10] is exposed about 1 mile north of Pleasant Ridge Church and School (Fig. 3) at the north end of a WPA dam (NE.1/4, Sec.11, T.6 S., R.4 E.). In the construction of the dam in 1936 a 12-foot marl layer was beveled by shovelling and scraping, and today affords perhaps the finest collecting of Ripley fossils any place in Mississippi. The lower 2-foot interval, about 3 feet above lake level, is consolidated in an irregular concretionary manner, and locally is composed largely of fossils. Unfortunately, the rock is too compact to permit ready separation of the individual specimens, but many species can be readily identified. The pelecypod *Liopistha protexta* and several species of gastropods are especially abundant. Many biscuit-shaped concretions 4 or 5 inches in diameter consist chiefly of crabs with the claws still attached, though it is practically impossible to free a specimen from its surroundings. For 12 feet above this layer the marl disintegrates readily, and the white shells of scores of species lie scattered about in great profusion, many of them nearly perfect.

Figure 3.—Pleasant Ridge Lake fossil locality in the lower Ripley marl. The excavating of material for a dam at the left exposed a 12-foot zone rich in well preserved fossils.—June, 1939.

A small collection was submitted to L. W. Stephenson[11] of the U. S. Geological Survey who recognized the species listed below.

LIST OF FOSSILS FROM THE SCRAPED AREA ON NORTH SIDE OF PLEASANT RIDGE LAKE. U.S.G.S. COLL. 18078—COLLECTED BY L. C. CONANT, A. BROWN, AND W. H. MONROE, JUNE 20, 1939.

Coelenterata:
- Micrabacia hilgardi Stephenson

Vermes:
- Hamulus onyx Morton
- Serpula lineata (Weller)

Mollusca:
- Pelecypoda:
  - Nucula percrassa Conrad, variety
  - Glycymeris rotundata (Gabb)
  - Breviarca sp.
  - Postligata crenata Wade
  - Inoceramus sp.

Ostrea tecticosta Gabb
Exogyra costata Say (medium costae)
Trigonia sp.
Pecten mississippiensis Conrad
Anomia argentaria Morton
Crenella serica Conrad
Pholadomya sp.
Liopistha protexta (Conrad)
Veniella conradi (Morton)
Vetericardia crenalirata Conrad
Crassatella vadosa Morton
Cardium (Trachycardium) eufaulense Conrad
C. (T.) sp. (fragment of large species)
C. (Granocardium) kummeli Weller
Corbula crassiplica Gabb
C. sp.

Scaphopoda:
Dentalium sp.
D. sp. (small, long, smooth)
Cadulus sp.

Gastropoda:
Pseudomalaxis ripleyana Wade
Calliomphalus americanus Wade (juvenile)
Urceolabrum sp.
Eulima sp.
Creonella cf. C. triplicata Wade
Proscala? sp.
Epitonium sillimani (Morton)?
Rissoina? tennesseensis Wade
Polinices rectilabrum (Conrad)
Turritella trilira Conrad
T. (several unidentified species)
Laxispira sp.
Anchura sp.
A. (?) sp. (several unidentified species)
Pugnellus densatus Conrad
Pyropsis sp.
Hercorhyncus tippanus (Conrad)
Saragana stantoni (Weller)
Morea cf. M. marylandica Gardner
Seminola solida Wade
Odontofusus curvicostatus Wade
O. sp.
Xancus? sp.
Drilluta? distans (Conrad)
D. sp.
D. ?
Paleosephaea? pergracilis Wade

Volutomorpha sp.
Volutoderma sp.
Paladmete cancellaria (Conrad), variety
P. sp.
Ringicula pulchella Shumard
Cylichna sp.
Unidentified gastropods; some belonging to undescribed genera from Navarro group, Texas.

This marl layer is believed to be about 150 feet above the base of the Ripley formation, a figure obtained by assuming a uniform dip of 30 feet per mile between here and the nearest outcrop of Selma chalk about 4 miles to the east, and 40 or 50 feet lower. It is at least 160 feet lower than the road corner half a mile to the northeast, which point is probably close to the top of the Ripley formation.

Scattered exposures along the small creek which enters the northeast corner of the lake indicate that the marl layer at the dam is about 60 feet below the McNairy sand of which about 25 feet is exposed in a deep gully at the head of the creek, not far from the road. Accordingly, the marl is referred to the Coon Creek member of the Ripley. The following discontinuous section (Secs.11, 12, T. 6 S., R.4 E.) shows this relationship:

SECTION FROM PLEASANT RIDGE LAKE TO HEAD OF CREEK

	Feet	Feet
Ripley formation, upper marine member		38
Lower 5-10 feet looks like weathered limestone; above that, typical upper Ripley soil	38	
Ripley formation, McNairy sand tongue		25
Sand, light-yellow and orange; practically no mica; fairly coarse; several thin corrugated, fluted, and tubular ferruginous sandstone zones; exposed in gully at head of creek	25	
Ripley formation, Coon Creek member		80
Sand, yellow, but without typical McNairy consolidated ferruginous zones	30	
Marl, blue micaceous mostly unfossiliferous. Upper limit marked by springs, lower limit concealed	22	
(Section down to here measured along creek, 1/4 to 1/2 mile east of dam. Section below here measured near dam)		
Clay, blue and sand, yellow, interbedded; a few very thin ferruginous sandstone layers	13	
Marl, blue highly fossiliferous; lower 1-2 feet locally consolidated, containing many fossils including crabs	12	
Covered to lake level; probably clayey material	3	

This marl layer is believed to lie very close stratigraphically to the better known fossiliferous beds at Lees Mill, which is about 3 miles to the west and about 60 feet lower. At the Lees Mill locality (SE. 1/4, Sec. 8, T.6 S., R.4 E.) which is about 2 miles north of Keownville by a winding road, and a few hundred feet south of the Tallahatchie bottom, there are two richly fossiliferous marl layers exposed beside the road, each several feet thick, and several feet apart. About 30 or 40 feet above the upper bed is an exposure of McNairy sand, only a few feet thick, which definitely places Lees Mill in the Coon Creek member of the Ripley.

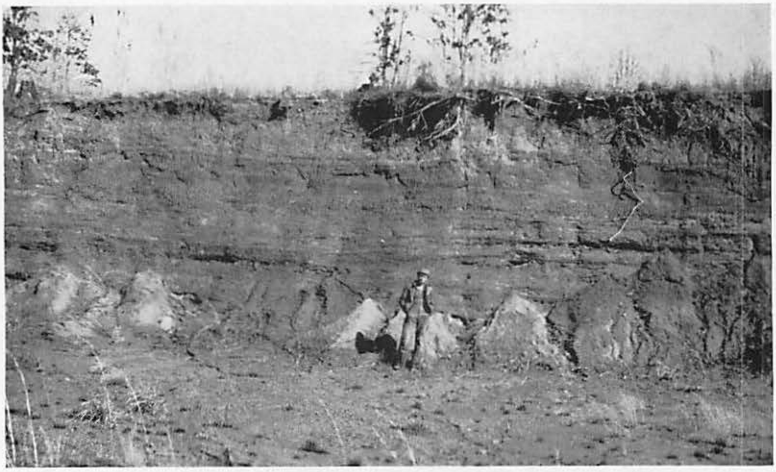

Figure 4.—Highway Department "sand" pit in black and gray clay and yellow sand, beside U. S. Highway 78, 3 miles northeast of Sherman.—February, 1939.

Another good, though small, exposure of Lower Ripley material can be seen beside U. S. Highway 78, 3 miles northwest of Sherman (Center, Sec.16, T.8 S., R.4 E.) in a pit where sandy material was obtained for road construction (Fig. 4). Here 15 to 20 feet of laminated black and gray clay and lenticular beds of yellow sand are exposed.

For half a mile northwest of this pit, the road rises steadily until it passes through a 40-foot cut at the top of the hill. Along the last several hundred feet approaching the cut are scattered exposures of blue marl, but in the cut itself at least some of the material is probably upper Ripley. A high bluff on the south side of the Frisco Railway track, 2 miles west of Blue Springs (Center, Sec. 5, T.8 S., R.4 E.), known locally as "Blue Cut," is a somewhat fossiliferous impure sandy marl doubtless belonging to the lower Ripley.

The McNairy sand, which receives its name from McNairy County, Tennessee[12], forms a great wedge or tongue-shaped mass which constitutes the greater part of the Ripley formation to the north in Tippah and Alcorn Counties, and in Tennessee. It is essentially a cross-bedded micaceous sand, somewhat ferruginous. Although typically exposed as a loose yellow sand, locally it has been consolidated by iron oxide to produce highly irregular tubular and corrugated sandstones which are readily recognized as belonging to this tongue (Fig. 5).

Figure 5.—Irregular corrugated and tubular ferruginous sandstone in the McNairy. Highway 30, about 3 miles east of Pleasant Ridge.—July, 1939.

In addition to the northward thickening of the McNairy at the expense of the upper and lower Ripley, it appears also to thicken eastward, from 25 feet near Pleasant Ridge Lake to 75 to 100 feet on Lebanon Mountain, some 6 miles to the east (half a mile beyond the Prentiss County line, Sec. 12, T.6 S., R.5 E.) where strongly indurated ferruginous sandstones, apparently McNairy, abound in the upper part of the mountain.

The presence of this sand is largely responsible for the rough topography north of Highway 30 from near Lees Mill to the Prentiss County line, and south of the Highway for a few miles from the vicinity of Pleasant Ridge. Near Pleasant Ridge these hills, which are a southern extension of the Hatchie Hills of Tippah County, form the watershed between the Hatchie, the Tallahatchie, and the Tombigbee stream systems.

The upper Ripley is characterized by more calcareous beds and sandy limestones. In the southern part of Union County these beds probably lie directly on the lower Ripley marls, sands, and clays, or similar materials of McNairy age, but in the northeastern part of the county the two sets of beds are separated by the McNairy sand tongue. No good exposure was found where the upper and lower beds were clearly in contact, though the highway cut 3 miles northwest of Sherman (Sec. 16, T.8 S., R.4 E.) referred to above is probably at or near the boundary.

The limestone of the upper Ripley crops out conspicuously in many places, especially on steep hill slopes and in some road cuts. About 1 mile northwest of Parks (E. edge, Sec. 8, T.7 S., R.4 E.) portions of it have been dissolved, producing broad flat "caves" which penetrate the hills a few tens of feet. Everywhere it is richly fossiliferous, containing large numbers of *Exogyra costata,* various species of *Cardium,* many smaller pelecypods, a variety of large and small gastropods, and many hemispherical echinoids (sea urchins) whose five radiating markings result in their local name of "star rocks". At a small exposure under a Gulf, Mobile & Ohio Railroad trestle (Sec. 16, T.6 S., R.3 E.) bryozoa are abundant, along with echinoids and *Exogyra.* Unusually fossiliferous specimens can be easily obtained at the road intersection mid-way between Center and Ellistown (Center, Sec. 21, T.7 S., R.4 E.) where freshly broken limestone boulders consist almost entirely of shells or shell impressions.

Several long but discontinuous sections in the upper Ripley are found in the east central part of the county, near Parks, where the high hills give way abruptly to the lower lands to the east. The following section, which is typical, both of the variety of material and of the discontinuity of outcrops, extends from beds overlying the Ripley to probable lower Ripley beds (Secs. 8 and 9, T.7 S., R.4 E.)

SECTION IN CREEK BED ON EAST-FACING ESCARPMENT OF PONTOTOC HILLS, NEAR PARKS

	Feet	Feet
Clayton formation, at least in part; marked by typical Clayton red soil with ferruginous concretions (native "gravel") between road level and hill tops; lower portion may be Prairie Bluff, 30 to		40
Prairie Bluff formation (probable), upper and lower limits not determined; at least		20
Zone of typical Prairie Bluff gray sticky soil	10	
Covered interval, may be Ripley in part	10	
Ripley formation; upper limit uncertain; about		125
Interbedded marl and limestone, badly weathered poorly exposed; upper part may be Prairie Bluff; about	30	
Marl	3	
Limestone, probably with subordinate layers of marl, but exposures poor; about	10	
Marl; about	15	
Sandy or quartzitic zone, containing abundant internal molds of *Cucullaea*	7	
Marl, blue	5	
Two nodular or concretionary layers; fossiliferous	2	
Marl, blue	10	
Limestone, very sandy bluish	1	
Marl, blue, practically continuous exposures; some zones rich in fossils	30	
Marl, blue sandy fossiliferous; 3 1-foot layers of impure blue sandstone within a 6-foot zone	12	
For about 300 yards below here the stream descends only 10 feet, the valley widens noticeably, and there are no exposures; probably lower Ripley.		

Another good section of the upper Ripley may be seen about 5 miles east of New Albany and a few hundred feet north of Highway 30 at a place known locally as "The Caves" (SW. 1/4, Sec.31, T.6 S., R.4 E.).

SECTION AT "THE CAVES," 5 MILES EAST OF NEW ALBANY, A FEW HUNDRED FEET NORTH OF HIGHWAY 30

	Feet	Feet
Prairie Bluff formation, upper part probably Clayton formation; badly weathered and no outcrops; float of ferruginous sandy concretions ("gravel") suggests presence of Clayton at the top of the knob; about		45
Ripley formation; about		75
Limestone, fossiliferous	4	
Covered, probably marl in part	10	
Limestone, fossiliferous sandy; a cave within this layer penetrates hill so that one can see through it; about	15	

Sandy material, probably weathered marl	3
Limestone, fossiliferous sandy	4
Marl, blue fossiliferous sandy; about	20
Sandstone, highly fossiliferous	1
Marl, blue sandy	3
Sandstone, massive highly fossiliferous, abundant internal molds of *Cucullaea*	5
Marl, blue sandy; base not exposed as creek flattens out; at least	10

Among the many other exposures of Ripley limestone in Union County are the following: (1) on the narrow ridge between Cane and Pinhook Creeks, notably near the east-west road south of Wells Chapel (S. edge, Sec. 11, T.6 S., R.3 E.), and at the south end of the ridge (N. edge, Sec. 34, T.6 S., R.3 E.) where low cliffs near the base on the west side can be seen several hundred yards away from the road which crosses Cane Creek; (2) in road cuts 2 miles south southwest of Wells Chapel (Center, Sec. 22, T.6 S., R.3 E.); (3) under the Gulf, Mobile & Ohio Railroad trestle 2 3/4 miles south of Cotton Plant (Sec. 16, T.6 S., R.3 E.); (4) along the east-west road 1 1/2 miles north of Locust Grove (Sec. 25, T.6 S., R.3 E., and Sec. 30, T.6 S., R.4 E.); (5) along an east-west road 2 1/2 miles east of Locust Grove School (Sec. 32, T.6 S., R.4 E.); (6) in the ravine back of Locust Grove School (NE. 1/4, Sec. 2, T.7 S., R.3 E.); (7) along the south wall of King Creek valley (Secs. 10-12, T.7 S., R.3 E.); (8) several places near the New Albany-Center road (notably near the bridge SE. Corner, Sec.9, near Centers, Sec. 13 and 15, T.7 S., R.3 E.); (9) just below an outlier of Prairie Bluff 2 miles east of Wallerville (SE. 1/4, Sec. 30, T.7 S., R.4 E.); (10) along an east-west road 1 mile south of New Harmony School (SW. 1/4, Sec. 18, T.8 S., R.4 E.); and (11) in the bed of Okonatie Creek a mile and a quarter east of Highway 15 (near W. edge, Sec. 16, T.8 S., R.3 E.).

It is difficult, because of weathering, to distinguish between the upper Ripley and the McNairy in the northeast part of the county, but it is probable that some of the area indicated on the geologic map (Pl. 1) as underlain by McNairy actually has some upper Ripley above it. Such a condition is shown between Pleasant Ridge and the Tippah County line.

All estimates of the thickness of the Ripley formation suggest a minimum of 300 feet. Thus, the top of Lebanon Mountain is about 300 feet above the Selma-Ripley contact at its base; the bottom of the Ripley near Ellistown and the top near New Albany are both about 375 feet above sea level, and if the oft-observed 30-foot dip prevails over the intervening 10 miles a thickness of 300 feet is indicated; similarly, the Pleasant Ridge Lake fossil bed is about 150 feet stratigraphically above the Selma-Ripley contact on Tishomingo Creek, and 165 feet below the nearby road corner, presumed to be near the top of the Ripley; and similar considerations suggest that the probable top of the Ripley, near the summit of Grubbs Mountain (Sec. 17, T.7 S., R.4 E.) is at least 285 feet stratigraphically above the Selma-Ripley contact near Ellistown.

The Upper Ripley limestones and the overlying Prairie Bluff chalk and Clayton limestone have resisted weathering and erosion more than the other rocks and are directly responsible for the Pontotoc Hills. The gentle inclination of these strata is reflected in the gently sloping ridges east of New Albany, the still higher summits near Pleasant Ridge, and the even higher summit of Lebanon Mountain.

PRAIRIE BLUFF CHALK

The Prairie Bluff chalk, named for Prairie Bluff on the Alabama River, in Alabama, has been variously considered a part of the Ripley formation, and the Oktibbeha tongue of the Selma chalk overlying the Ripley, but recently Stephenson and Monroe[13], on the basis of a widespread unconformity at its base, established it as a separate formation. Toward the north, it merges upward into the Owl Creek formation to which it gives way entirely in Tippah County. Because of the similarity and intergradation of the two units, no attempt has been made in this work to map them separately, though at a number of places in Union County Stephenson and Monroe[14] have recognized several feet of Owl Creek material above the Prairie Bluff chalk.

In Union County the Prairie Bluff chalk is impure and shows a dark blue-gray color when freshly exposed. Typically it contains many fossils, though less than characterize the famous Owl Creek beds farther north. Notable among the fossils in Union County are *Bacculites, Scaphites,* and a few *Exogyra costata* and small echinoids.

Fresh exposures of the formation are not abundant in Union County except along some of the railway and highway cuts; more commonly it is exposed as a weathered blue-gray sticky calcareous clay. Along many unimproved roads its gray dust or mud contrast strikingly with the red colors produced by the Ripley and Clayton beds. Nowhere was it found in clear contact with both overlying and underlain formations, but, as nearly as could be determined, its thickness is somewhat variable, averaging about 40 feet.

Among the places where it is well exposed are the following: (1) many places along the narrow ridge between Cane and Pinhook Creeks, especially on the east-west road south of Wells Chapel (S. edge, Sec. 11, T.6 S., R.3 E.); (2) beside new Highway 15, 2 1/2 miles south of Cotton Plant (Sec. 16, T.6 S., R.3 E.) where a 25-foot interval is exposed in a cut beneath weathered Clayton; (3) on the west side of the Lukesaspa Creek valley beside an east-west road 3 miles south of Cotton Plant (NE. 1/4, Sec. 20, T.6 S., R.3 E.); (4) in a small Frisco Railway cut just west of the Tallahatchie bridge, 1 mile west of the New Albany station (Fig. 6); (5) along a stream ditch beside and below the Frisco Railway tracks in the east part of New Albany; (6) in the Frisco Railway cut 1 1/4 miles south-

Figure 6.—Prairie Bluff chalk beside the Frisco Railway 1 mile west of New Albany.—March, 1939.

east of New Albany; (7) in the Frisco Railway cut 1 mile northwest of Wallerville; (8) in the Frisco Railway cut at Wallerville; (9) 2 miles south of New Albany on the steep slope overlooking the Gulf, Mobile & Ohio Railroad track and the Tallahatchie bottom; (10) 3 1/4 miles south of New Albany beside Highway 15 on the south wall of King Creek; and (11) 6 and 7 miles south of New Albany in cuts along the same highway on the north and south walls of Okonatie Creek.

Because it is very different from the underlying upper Ripley strata and the overlying Clayton limestone, in both fresh and weathered exposures, as well as in its fauna (notably the presence of *Baculites* and *Scaphites*), the Prairie Bluff formation is fairly easy to trace when one knows his approximate stratigraphic position. Although its main outcrop belt extends in an essentially north-south direction across the county through New Albany (Pl. 1), many pronounced eastward extensions of the formation are near the tops of ridges and as outliers east of the main outcrop belt. The fact that such a thin bed is abundantly exposed over a belt 7 or 8 miles wide bespeaks the influence which it, together with the overlying Clayton and underlying Ripley, has had on the development of the topography.

Unfortunately, it resembles superficially some of the marls of the lower Ripley, so that in at least one instance the two have been confused, with the consequent loss of many thousands of dollars on the part of Union County citizens who invested in oil well speculations (See Structural geology).

One of the best exposures for determining the thickness of the formation is 1 1/2 miles east of New Albany on the steep east wall of King Creek (NW. corner, Sec. 15, T.7 S., R.3 E.). The Ripley limestone is exposed alongside the creek just south of the road; and about 40 feet above that the upper contact of the Priarie Bluff shows plainly in the road ditch, though the material is badly weathered. Along Highway 15 on the south wall of King Creek discontinuous outcrops suggest the presence of about 45 feet of Prairie Bluff material.

The Prairie Bluff, together with the Owl Creek, is the youngest Cretaceous formation exposed in Mississippi and is separated from the overlying Clayton formation by one of the most widespread unconformities in the Atlantic and Gulf Coastal province.

STRATIGRAPHY—CENOZOIC GROUP

PALEOCENE SYSTEM—MIDWAY SERIES

The Midway series, named for Midway Landing on the Alabama River in Alabama, is the oldest of the Cenozoic strata exposed in Mississippi. Until recently the Midway has been considered the basal portion of the Eocene system in Mississippi, but with the adoption of the term Paleocene by the U. S. Geological Survey it is now included in that division. In northern Mississippi the Midway consists of the

Clayton formation and the Porters Creek clay, and is separated from the overlying Wilcox series (Eocene) by an important unconformity.

CLAYTON FORMATION

GENERAL FEATURES

The Clayton formation, named for the town of Clayton, Alabama, consists in northern Mississippi of two distinct members: (1) a basal limestone and marl member, and (2) an upper marl, clay, and sand member. Hilgard[15] assigned the limestone member to the Mesozoic (Cretaceous), but Harris[16] later showed it to be of Cenozoic age.

Unweathered exposures of the Clayton formation are relatively rare in Union County, and most of those are only a few feet thick, so that both the thickness and the details of its strata are difficult or impossible to obtain with certainty unless it were from a well. In Tippah County the formation appears to range from 50 to 75 feet in thickness, and a similar or slightly less thickness probably prevails in Union County.

The fertile soil derived from the Clayton formation has been described by earlier writers as having an Indian red color, but typically only the upper, or marl, member yields this brilliant red soil, whereas the limestone produces a dirty straw or ocher color. In most road cuts this color difference is conspicuous, though at the surface where weathering has been more profound it is often difficult to distinguish one soil from the other. Among the places where this contrast shows well are: (1) the cut on Highway 30, 1 mile west of New Albany where the road leaves the Tallahatchie bottom; (2) the New Albany-Center road, a short distance east of a T.V.A. substation (SW. 1/4, Sec. 9, T.7 S., R.3 E.); (3) the road cuts about 150 yards west of Center School (NE. corner, Sec. 24, T.7 S., R.3 E.); and (4) a sand pit near Wallerville on new U. S. Highway 78 (Sec. 26, T.7 S., R.3 E.) where the contact is plainly visible, and where both limestone and marl have weathered to a sand which was used in the construction of the highway.

The presence of a persistent concretionary, or "gravel," zone (Fig. 7), which results from weathering of the upper member, made it necessary locally to extend the outcrop area of the Clayton formation 5 or 6 miles farther east than it had been recognized previously.

Throughout the Clayton outcrop area, the surface tends to rise to the east about 30 feet a mile, corresponding in general to the up-dip of the underlying strata, until it is interrupted by an abrupt escarpment facing the lower land farther east (Fig. 2). That a few

Figure 7.—Ferruginous concretions in the lower part of the upper Clayton. Highway 30 near Locust Grove.—January, 1939.

feet, at least, of Clayton material extends practically to the eastern limit of the higher hills bespeaks its resistance to erosion, and the part it has played in holding up the Pontotoc Hills.

BASAL MEMBER

The fresh Clayton limestone is light-gray in color, somewhat stained yellowish-brown by the weathering of its glauconite grains. It is hard, crystalline, commonly contains an abundance of glassy-looking quartz grains, and is highly fossiliferous. Most distinctive among its variety of fossils is a high-spiraled snail, *Turritella mortoni*, whose abundance has caused the rock to be termed "Turritella" limestone. Commonly, only the external impressions and corkscrew-like internal molds of the *Turritella* are preserved. On weathering the limestone yields various irregular forms so that it is occasionally referred to as a "horsebone" limestone.

The thickness of the basal member in Union County is unknown, but probably is about 15 feet. Associated with the limestone are subordinate layers of fossiliferous sandy glauconitic marl.

Fresh exposures of the Clayton limestone are so uncommon in Union County that it seems worthwhile to list those exposures which have been observed. They are: (1) several places along the west wall of Lukesaspa Creek (Secs. 5, 8, 17, 20, T.6 S., R.3 E.); (2) on the hill slope west of the road corner 3 1/2 miles south of Wells Chapel (Sec. 27, T.6 S., R.3 E.); (3) in the Frisco Railway cut on the east edge of New Albany (SW. 1/4, Sec. 9, T.7 S., R.3 E.); (4) 2 miles south of New Albany on the steep slope overlooking the Gulf, Mobile & Ohio Railroad and the Tallahatchie bottom (SE. 1/4, Sec. 18, T.7 S., R.3 E.); (5) beside Highway 15 on the south wall of King Creek (NW. 1/4, Sec. 29, T.7 S., R.3 E.); and (6) at the site of a small cave and sinkhole beside the Gulf, Mobile & Ohio Railroad track 4 miles south of New Albany (Center, Sec. 25, T.7 S., R.2 E.). Two other limestone outcrops in the county appear to represent a thin interval in the upper Clayton, and are mentioned later.

UPPER MEMBER

The upper, so-called marl, member of the Clayton is here considered to include all the strata above the basal 15-foot member in which limestone layers are conspicuous. Owing to the paucity of good exposures, it is uncertain how thick either member is, but is is probable that in Union County the upper member is at least 50 feet thick. This member appears to consist chiefly of dark laminated clays, thin laminae of sand, and subordinate layers of marl. Certain layers are noticeably fossiliferous, the fossils consisting either of plant or of shell fragments.

Two limestone outcrops in Union County appear to represent an interval; perhaps a foot thick, near the middle of the upper Clayton—an interval recently noted[17] near Ripley in Tippah County as being about 30 feet above the base of the formation. In Union County one of these outcrops, close to the Tippah County line, is half a mile southwest of Cotton Plant on the old New Albany road near the foot of the west wall of Lukesaspa valley (NW. 1/4, Sec. 5, T.6 S., R.3 E.); the other is on the Pontotoc County line 1 1/2 miles west of Highway 15 in a small stream ditch on the north side of the county line road (SW. Cor., Sec. 13, T.8 S., R.2 E.). The first outcrop is assigned to this member as it is only about 30 feet below an exposed Clayton-Porters Creek contact three-quarters of a mile to the northwest; the second is so assigned because it is so far above the presumed position of the base of the formation.

The following section affords the best known exposure of the lower and upper Clayton in contact in Union County:

SECTION OF THE STEEP SLOPE OVERLOOKING THE GULF, MOBILE & OHIO RAILROAD TRACK AND THE TALLAHATCHIE BOTTOM 2 MILES SOUTH OF NEW ALBANY

	Feet	Feet
Clayton formation; about		53
Typical Indian red soil extending to the top of hill; about	35	
Clay, laminated, containing thin laminae of sand; on weathered surface contains ferruginous sandy concretions or "gravel"	5	
Covered	3	
Limestone, fossiliferous sandy	10	
Prairie Bluff marl; several good exposures of fresh blue fossiliferous material, lower contact not exposed		35

Another section, near the northern edge of the county (Sec. 8, T.6 S., R.3 E.) exhibits essentially unweathered upper Clayton strata where they have been exposed by recent road improvements:

SECTION BESIDE OLD NEW ALBANY-COTTON PLANT ROAD 1 1/2 MILES SOUTH OF COTTON PLANT

	Feet	Feet
Clayton formation		35
Clay, bluish-gray laminated, and abundant thin laminae of sand; upper portion contains purer clay layers some of which resemble Porters Creek clay; lower portion more carbonaceous and contains much comminuted plant material (corresponding beds exposed in road ditch 1/4 mile to south are cross-bedded)	22	
Sand, stratified yellow	1	
Clay, bluish-gray, thin sand laminae, a few poorly preserved plant remains	6	
Clay, slightly laminated glauconitic bluish-brown and greenish-brown, highly fossiliferous; lower 1 foot indurated, practically a limestone	6	

In a few places a cross-bedded grit-bearing sand containing scattered quartz or quartzite pebbles up to 1/2 inch in size has been observed just above the top of the basal member: (1) 4 miles north of New Albany on old Highway 15 (NE. 1/4, Sec. 28, T.6 S., R.3 E.) where it is 1 to 2 feet thick; and (2) 1 mile west of New Albany on Highway 30 in a cut on the west side of the Tallahatchie bottom (N. edge, Sec. 7, T.7 S., R.3 E.) where it is 3 feet thick.

In many places a gravel-like material has developed in at least the lower part of the upper member where prolonged weathering has formed ferruginous sandy concretionary lumps ranging in size from less than an inch to a foot or more. Locally these concretions are so abundant at or near the surface that they have been used for a low-grade road gravel. One such "gravel" pit is along the top of Union Hill (a ridge extending from Sec. 13 to Sec. 15, T.7 S., R.3 E.). Material from here is reported to have been hauled as much as 6 or 8 miles for use on county roads. It is a poor substitute for actual gravel as it is ground up by impact with horseshoes and wagon or truck wheels. Near Locust Grove School (Secs. 1 and 2, T.7 S., R. 3 E.) some 4 miles east of New Albany, 10 to 15-foot cuts for Highway 30 expose a layer 3 or 4 feet thick of the concretionary pebbles, those near the base being as much as a foot in diameter (Fig. 6).

So general is the tendency for weathering to produce this "gravel" that it has been possible, with caution, to use such material as a horizon marker in mapping the outcrop area of the Clayton formation. Thus the presence of Clayton on the high summits of Grubbs Mountain and nearby hills (Secs. 5, 8, 17, T.7 S., R.4 E.) is strongly suggested by the red "gravel"-strewn slopes, by altimeter readings, and by the presence of badly weathered apparent Prairie Bluff material between it and upper Ripley limestone exposed about 75 feet below the top of the mountain.

PORTERS CREEK CLAY

The Porters Creek clay, named for Porters Creek at Middleton, Tennessee[18], is a dark-gray montmorillonitic marine clay which underlies the Flatwoods.

Its contact with the underlying Clayton formation is conformable and somewhat gradational in that some of the upper Clayton laminae are much like the Porters Creek clay, and the basal phase of the Porters Creek clay is glauconitic, as is the Clayton. At the type locality at Middleton, Tennessee, and throughout most of Tippah County the contact is considered to be a zone several inches thick which is a fine-grained indurated glauconitic siltstone, but in southern Tippah and in Union County this indurated layer is much less conspicuous. The actual Clayton-Porters Creek contact has been found in only two or three places in Union County, because of the absence of the strong contact layer. The only places where the contact has been seen are: (1) a small exposure in a ditch beside old U. S. Highway 78, 1 mile north of Glenfield (S. edge, Sec. 30, T.6 S., R.3 E.); and (2) two road cuts south of Bethlehem Church (W. edge, Sec. 17, T.6 S., R.3 E.).

In Tippah County at least three other similar layers of the indurated glauconitic siltstone are known at higher horizons in the Tippah sand member, and scattered outcrops of similar material within the Porters Creek in Union County are believed to represent their southern equivalents.

At no place in Union County has it been found possible to determine with any reliability either the thickness or the angle of dip of the Porters Creek clay as a whole, though at a few places distinct dips were observed in the laminated upper portion. In Tippah County the formation is 200 to 250 feet thick. Measurements in other localities indicate a westward dip of about 15 feet per mile[19]. If such a dip prevails in Union County, the formation can hardly be 150 feet thick, yet evidence in the Pinedale section suggests that the laminated upper phase alone may have a thickness considerably greater than that. The thickest single exposure of the formation in the county is along a road which descends the steep east wall of Locke Creek (SW. 1/4, Sec. 5, T.7 S., R.2 E.) where 85 feet of the clay is seen in sharp contact with 35 feet of overlying Wilcox material.

Casual inspection suggests that the Porters Creek clay is nearly uniform throughout both its vertical and horizontal extent, whereas careful observation reveals significant vertical variations. The lower portion is sufficiently glauconitic to weather to a brilliant red soil hardly to be distinguished from the Clayton soil, the middle portion is massive gray clay—typical Porters Creek—and the upper part is so strongly laminated and micaceous as to be readily confused with the higher Ackerman clays. This upper portion is probably a northern extension of the Naheola formation of Alabama, which has recently been recognized in Winston and Lauderdale Counties, Mississippi[20, 21].

BASAL PHASE

The basal portion of the formation, some 50 feet thick, is silty, greenish-black, glauconitic, bentonitic, and somewhat harder than the typical material. A good exposure of this phase is 4 miles west of New Albany along Highway 30 on the west wall of Hell Creek valley (Sec. 10, T.7 S., R.2 E.) where the Clayton-Porters Creek contact is probably not many feet below floodplain level at the foot of the hill. The lower part of the Porters Creek exposure has a somewhat bentonitic appearance which persists in less degree to the top of the slope where a partially indurated glauconitic siltstone layer about 1 foot thick seems to be responsible for a large flat area about 30 feet above the floodplain. This rock layer may be equivalent to similar material in the Tippah sand member in northern Tippah County[22].

About 1 1/4 miles west of here two similar rock layers are exposed near the Will Hale place on the east wall of Little Mud (Ayres) Creek along a road leading northwest from Union School (Center, Sec. 9, T.7 S., R.2 E.).

SECTION BESIDE ROAD AT WILL HALE PLACE

	Feet	Feet
Porters Creek clay		20
Siltstone, hard glauconitic	1	
Clay, dark-gray, conchoidal fracture	8	
Siltstone, hard glauconitic	1	
Clay, dark-gray, conchoidal fracture	10	

As the lower siltstone layer is only 15 or 20 feet lower than the one near Hell Creek, it seems likely that these are two outcrops of the same layer in which case the dip between them would be about 10 or 15 feet a mile.

Other good exposures of this indurated material in Union County are: (1) near the Tippah County line 2 1/2 miles west of Cotton Plant (NW. Cor. and Center, Sec. 1, T.6 S., R.2 E.); and (2) 3 miles east of Myrtle (NW. 1/4, Sec. 14, T.6 S., R.2 E.) on an east-west road about a quarter of a mile east of its junction with a north-south road.

Because of its glauconite and silt content the basal phase of the Porters Creek clay weathers to a sticky silty red clay soil which can be distinguished from the Clayton soil only with difficulty, if at all, well demonstrated on the low ridge between Hell and Damnation Creeks (Secs. 1, 12, 13, and 24, T.6 S., R.2 E.) and near Hill School about 3 miles west of Ingomar (Sec. 4, T.8 S., R.2 E.), in both of which places the soil over large areas has every appearance of being Clayton-derived, yet nearby outcrops of glauconitic Porters Creek clay at lower elevations reveal its true parentage.

Because of this similarity of soils and the paucity of outcrops, the Clayton-Porters Creek contact could be mapped only in a most general way between Highway 30 and the Pontotoc County line.

MIDDLE OR TYPICAL PHASE

The basal phase grades upward into a massive plastic clay composed largely of montmorillonite[23]. This, the typical phase of the Porters Creek, is dark-gray when wet, light-gray when dry. It contains relatively little silt and mica, shows almost no stratification, but possesses a marked conchoidal fracture, causing it to break out into lumps from 1 to 4 inches in diameter. When cut with a knife its texture is much like soap, and the smooth surfaces commonly show minute yellow laminae probably composed of very fine glau-

Figure 8.—Porters Creek clay in a 50-foot bluff of Locke Creek, C. J. Meyers property.—February, 1939.

conitic silt. Although for the most part devoid of megascopic fossils, it does contain microscopic foraminifera[24].

The thickness of this phase of the clay in Union County has not been determined, though it constitutes all or most of an 85-foot exposure on the steep east wall of Locke Creek (SW. 1/4, Sec. 5, T.7 S., R.2 E.), at which place it is overlain by Wilcox strata.

Another good exposure of this material is on the C. J. Myers place (SW. 1/4, Sec. 24, T.6 S., R.1 E.) where a 50-foot bluff (Fig. 8) rises steeply on the southwest bank of the stream. Scattered throughout the county are many other smaller exposures which are readily recognizable as being of typical Porters Creek clay.

UPPER PHASE

In many places the upper part of the Porters Creek formation consists of a strongly-laminated highly micaceous and silty blue-black clay having scattered thin layers of more typical massive Porters Creek clay. Interbedded with this are fine-grained micaceous cross-bedded sands ranging in thickness from a few inches to several feet. Locally concretions of siderite (paint rock) abound[25]. The upper phase is probably a northern extension of the Naheola formation of Alabama and of Winston and Lauderdale Counties in Mississippi, though it has not been mapped separately in Union County.

This material is abundant in the western part of the Porters Creek outcrop belt: (1) about 1 1/4 miles northeast of Darden in the road cuts on both sides of the north-south valley (E. 1/2, Sec. 34, T.6 S., R.1 E.); (2) about 3 1/2 miles by road northwest of Macedonia on the G. C. Rhea property, on the Marshall County line (NW. Cor., Sec. 31, T.6 S., R.1 E.), where a ditch beside an east-west road exposes a 10-foot laminated sand-silt-clay zone, carrying siderite concretions is overlain by 16 feet of more typical though somewhat silty Porters Creek clay; (3) on and near Highway 30 just east of the Tallahatchie bridge at Rocky Ford (Sec. 8, T.7 S., R.1 E.) in the lower slopes of the roads both north and east of the road corner; (4) in a road ditch north of Highway 30 just below a sand pit at Enterprise (Sec. 13, T.7 S., R.1 E.); (5) a quarter and a half a mile west of Salem Church (W. 1/2, Sec. 33, T.7 S., R.1 E.) in and on both sides of a north-south valley—respectively near the Busby bauxite pit on the east side of the valley, and in a steep bluff on the west side of the valley where there are siderite concretions; (6) about 1 mile south of the Busby bauxite pit on the east bank of a stream (Sec. 5, T.8 S., R.1 E.) where a thickness of 30 to 35 feet of glauconitic silty sand with laminae of Porters Creek clay is exposed; (7) in the bed of the stream on the O. D. Gray place (Center, Sec. 4, T.8 S., R.1 E.); and (8) two-thirds of a mile southeast of the Pinedale crossroads, in a stream bed where concretions abound (SE. 1/4, Sec. 10, T.8 S., R.1 E.).

At the O. D. Gray place abundant siderite concretions are typically from 1 to 6 feet in horizontal diameter and up to 12 inches in thickness. The strata show pronounced southwesterly dips of 2 to 8 degrees over a distance of several hundred yards. If this be a true dip, as it appears to be, and not cross bedding, there must be exposed here a thickness of fully 100 feet of the laminated phase of the Porters Creek or Naheola, while at least another 50 feet is present above in the hill to the west. If the material be as thick, as it here appears to be, it is the thickest exposure known in Mississippi.

To the southwest, deep wells commonly penetrate 500 to 800 feet of Midway material, and it appears that the series is so overlapped by Wilcox beds that its full thickness is nowhere revealed at the surface. Thus, the laminated portion, or Naheola, is exposed only along the western edge of the Midway belt in both Tippah and Union Counties, and in Tippah County the Wilcox beds have locally overlapped all but the lower member of the Porters Creek clay[26].

BAUXITE-KAOLIN ZONE

At many places in Mississippi, including a few in Union County, local deposits of kaolin and bauxite lie directly on Porters Creek clay, from which they appear to have been derived. Typically the kaolin grades downward through several feet of increasingly silty and micaceous clay to where the white color of the kaolin gives way to yellowish and ocherous shades which in turn grade downward into the blue-black micaceous and silty Porters Creek clay. Where bauxite is present it, in turn, overlies and grades downward into the kaolin. In 1922, William C. Morse and Paul F. Morse made a thorough examination of most of the then known Mississippi bauxite[27].

An excellent illustration of this downward gradation was found during the present work in Union County in the old Busby bauxite pit on the top of a small hill overlooking a stream valley, about a quarter of a mile due west of Salem Church (N. edge, SW. 1/4, Sec. 33, T.7 S., R.1 E.). The log of test hole D187 (Test hole records) shows this gradation.

There has long been doubt concerning the origin of bauxite, but it now appears reasonably certain that these kaolin and bauxite deposits were formed by weathering during the long interim between the deposition of the Porters Creek clay and the deposition of the overlying Wilcox strata. In 1936 Bramlette[28] suggested that some low-grade bauxite and kaolin in Arkansas had been formed from an underlying blue clay similar to the Porters Creek clay and correlated with it. In 1937 Mellen[29] attributed some earlier Mississippi kaolin to similar processes; and in 1939 he[30] stated that all the known Mississippi bauxite and all the kaolin lying on the Porters Creek clay has been produced by weathering of that clay during the Midway-Wilcox interval, and proposed that these residual deposits be considered a separate formation, the "Betheden". More recently the present writer has suggested[31] that erosion shortly prior to Wilcox time removed most of the bauxite leaving erosional remnants of once more extensive deposits.

Not all the bauxite deposits in Mississippi lie directly on the parent Porters Creek clay, for some are found at various distances above the Midway-Wilcox contact in the overlying sand. A good example[32] is on the J. H. Carnal property (NW. 1/4, Sec. 9, T.7 S., R.1 E.), where the present investigations show it to be a 4-foot bed separated from the underlying Porters Creek clay by 18 feet of Wilcox sand and clay.

SECTION OF THE J. H. CARNAL BAUXITE DEPOSIT

	Feet	Feet
Wilcox		22.9
Soil and subsoil	1.0	
Bauxite	3.8	
Sand, red	13.8	
Clay, white very sandy	3.3	
Sand, red	1.0	
Clay, probably Porters Creek		1.7

It is probable, as suggested by Mellen[33] that such deposits represent a reworking and deposition of the old bauxite soil shortly after the beginning of Wilcox time.

It is interesting to note that all the Arkansas bauxite was developed at the same time and by similar processes as the Mississippi bauxite, but it is not encouraging to realize that the high-grade Arkansas material was derived from a feldspar-rich syenite, a rock quite different from anything found at the surface in Mississippi.

PALEOCENE-EOCENE OR MIDWAY-WILCOX CONTACT

Nearly all previous publications on the geology of Mississippi state that the contact between the Porters Creek clay and the overlying formation is gradational. If present ideas concerning the origin of the bauxite and kaolin be correct, however, there must be an important unconformity between the two formations. Furthermore, wherever the exposures are fresh, a sharp contact can be seen, as in Highway 30 cut about half a mile southwest of the Tallahatchie bridge at Rocky Ford (Fig. 9). Other good exposures of the contact are: (1) just north of Myrtle in the ditch on the west side of the road (Center, Sec. 17, T.6 S., R.2 E.) where red sand, breccia, and clay make up the Wilcox; (2) on the road 1 mile west of Myrtle

Figure 9.—Paleocene-Eocene contact. Midway light clay below; Wilcox red sand above. Highway 30, one-half mile west of Rocky Ford.—February, 1939.

(Secs. 18 and 19, T.6 S., R.2 E.) where the contact dips noticeably westward; (3) on the steep east-facing slope along an abandoned east-west road 3 miles southwest of Myrtle (E. edge, Sec. 26, T.6 S., R.1 E.) where a 20-foot interval of laminated Porters Creek or Naheola clay is overlain by impure nearly white clay, the upper few inches of which consists of soft white bauxite, separated from about 25 feet of overlying cross-bedded red sand by a line-sharp unconformity; (4) in a road cut on the west-facing slope 1 1/2 miles northeast of Darden (E. edge, Sec. 34, T.6 S., R.1 E.) where a 20-foot exposure of Porters Creek clay is overlain by cross-bedded yellow sand and white sand containing clay breccia fragments; (5) 2 miles north of Rocky Ford (SE. Cor., Sec. 31, T.6 S., R.1 E.) where laminated Porters Creek clay, dipping about 5 degrees northward, is separated from overlying Wilcox sands by an unconformity parallel with the laminated clay; (6) on the west side of the narrow ridge 3 miles due west of Glenfield just below a Wilcox sand pit (SW. Cor., Sec. 34, T.6 S., R.2 E.); (7) on the steep west-facing slope 2 miles north of Pooleville (SW. 1/4, Sec. 5, T.7 S., R.2 E.) where an 85-foot exposure of Porters Creek clay is overlain by 35 feet of Wilcox sand; (8) at several places along the road leading north from Highway 30 at Enterprise (Secs. 12 and 13, T.7 S., R.1 E.); and (9) in the long-since abandoned Pontotoc-Memphis road about three-quarters of a mile south of Salem Church (NE. 1/4, Sec. 4, T.8 S., R.1 E.).

Previous confusion as to the nature of this contact seems to have been due to: (1) failure to recognize the residual origin of the kaolin and bauxite, (2) failure to recognize the presence of the Fearn Springs beds and Ackerman sand at the base of the Wilcox, and (3) failure to recognize the fact that the upper Porters Creek, or Naheola, may be as distinctly laminated as the Wilcox clay.

The facts here cited regarding the unconformity, and the duration of the interval represented by it, offer strong support for the removal of the Midway strata from the Eocene and their assignment to a new system or series, the Paleocene, as has been done recently by the United States Geological Survey.

EOCENE SYSTEM—WILCOX SERIES

The Wilcox series, named for Wilcox County, Alabama, overlies the Midway in Mississippi, and, with the establishment of the Paleocene system, it becomes the basal Eocene series in the state. Only the two lowest formations of the series, the Fearn Springs and the Ackerman, have been recognized in Union County.

FEARN SPRINGS FORMATION

Mellen[34] has found that the Midway beds in Mississippi are typically overlain by a series of silts and sands, lignite beds, lignitic clays, and light-colored clays, and that these in turn are overlain unconformably by the Ackerman formation. To these beds he has applied the term Fearn Springs formation. Foster[35] has found the Fearn Springs formation to be equivalent to the Coal Bluff beds of Alabama.

The Fearn Springs beds are well exposed at many places in northwestern Union County, and nearby portions of Benton County, where they have an apparent thickness of at least 115 feet. In other parts of the county they are largely or entirely missing, so that the Ackerman sands lie directly on the Porters Creek clay.

In Union County the Fearn Springs, in its more complete section, consists of a basal sand, some 10 to 20 feet thick, commonly brown and fine-grained, but locally coarse-grained. The sand is overlain by an irregular series of gray or lignitic silty plastic clays and laminated micaceous silty clays and sands which locally are strongly cross-bedded.

In some places siderite concretions are present, in others as many as three probable siderite layers a few inches thick and a few feet apart are found.

The typical fine-grained brown micaceous silt or sand of the basal portion is well exposed about 2 1/2 miles west of Myrtle beside an improved road near the foot of the hill on the east side of a valley (SE. 1/4, Sec. 14, T.6 S., R.1 E.) and 3 1/2 miles farther west along the same road (near E. edge, Sec. 20, T.6 S., R.1 E., which is also 2 miles east of Cornersville, a community just over the line in Marshall County). At both of these places are good exposures of the overlying irregular silty clays. At the last-mentioned locality the clays show, at the top of the hill about 50 yards east of the sand exposure, three ferruginous rock layers which, when fresh, were probably siderite. The coarse phase of the basal beds is well exposed in a small sand pit just south of the Benton County line and about 100 yards north of the junction of old and new U. S. Highways 78 (Sec. 6, T.6 S., R.2 E.). The sand here contains petrified wood fragments.

Plastic clays and lignite, both locally present in the formation, have been shown by Foster[36] to lie above the basal sands and below a thick series of cross-bedded laminated silty clays. Good exposures of these clays showing their relationship to adjacent materials have not been noted in Union County, though the succession pointed out by Foster seems to apply here also.

Strongly cross-bedded clays, believed to be uppermost Fearn Springs, are exposed about three-quarters of a mile southeast of Blythe School beside a dirt road 0.4 mile south of the improved east-west road (SE. 1/4, Sec. 8, T.6 S., R.1 E.) where distinctly laminated micaceous silty clays and interbedded sands show southerly dips as steep as 20 degrees. Half a mile beyond the Benton County line, cuts for new U. S. Highway 78 show silty clays having westerly dips of 7 to 10 degrees (Fig. 10), and the same materials are exposed even better half a mile farther northwest in the deep "blue cut" of the Frisco Railway (not to be confused with the "blue cut" near Blue Springs), where Lowe[37] described these as Ackerman clays. For 1.5 miles along old U. S. Highway 78 in Benton County, commencing at the grade crossing near the Union County line, scattered exposures indicate a thickness of about 115 feet of the Fearn Springs formation, consisting of sand at the base, plastic and lig-

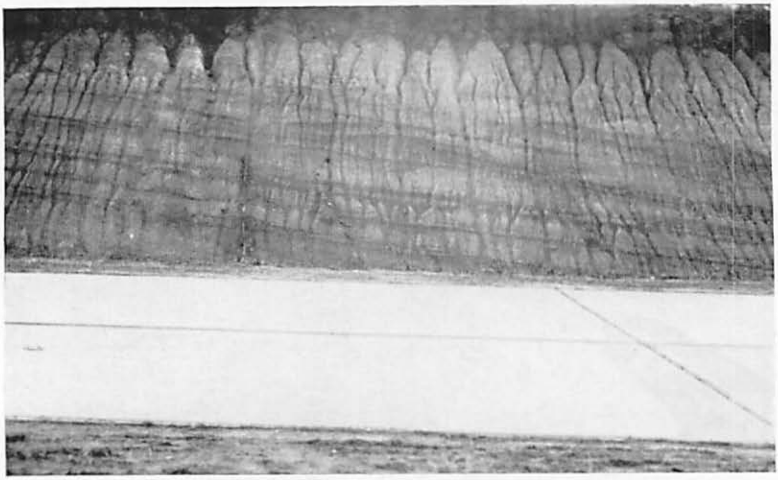

Figure 10.—Fearn Springs laminated cross-bedded clay. Highway 78, one mile northwest of the Union-Benton County line.—January, 1939.

nitic clays in the middle, and cross-bedded, laminated silty clays at the top, above all which are excellent exposures of basal Ackerman sand.

In northwestern Union County the Fearn Springs formation probably underlies almost all of one entire Township (T.6 S., R.1 E.) and the few square miles of Wilcox terrain to the east (Pl. 1).

Much of the clay in this formation, as pointed out by Mellen[38], probably represents a reworking of the weathered products in the underlying bauxite-kaolin zone. Some of the plastic clays are probably suited for various commercial uses. Siderite in the formation has been worked in Benton County, a few miles beyond the bounds of Union County.

On the geologic map (Pl. I) the Fearn Springs formation has not been shown separately, but together with the Ackerman formations included in the Wilcox.

ACKERMAN FORMATION

The Ackerman formation, as now restricted, lies unconformably on the Fearn Springs formation or, where that formation is missing, lies directly on the Midway beds—either the true Porters Creek clay or the probable Naheola beds. The Ackerman consists of a basal sand bed and overlying laminated clays. Some years ago Grim[39] recognized a persistent thick sand bed at or near the base of the Ackerman; more recently Mellen[40] has described the same bed in greater detail in Winston County where he found it actually underlying Ackerman clay; still more recently it has been noted in Lauderdale[41] and Tippah[42] Counties. Because this basal sand is not exposed at the type locality of the Ackerman formation described by Lowe[43], and because it closely resembles the still higher and thicker Holly Springs sand, it has been generally overlooked until recent years.

At its base in Union County, the Ackerman sand typically contains a coarse grit and scattered boulders, some a few inches in diameter, though even larger ones have been reported from Winston[40] and Tippah[42] Counties. Petrified wood fragments are also common in this sand and have been found by the present writer in Tippah, Benton, and Union Counties. One 900-pound slab of wood, from a hill slope in the woods just above the Midway-Wilcox contact level in southern Benton County (SW. 1/4, Sec. 32, T.5 S., R.2 E.), is now on display at the University of Mississippi.

The source of the boulders and their method of transportation at a time when streams were apparently capable of carrying only ordinary sand are unknown. Rafting by floating ice would require a temporarily severe climate for which there is no evidence, while rafting by uprooted trees would presuppose the presence of many more such trees than the scattered petrified wood fragments indicate.

In places the sand contains many light-colored angular or rounded chunks of clay, forming a clay-ball breccia. Apparently the breccia reflects unusual topographic or drainage conditions, or both, which resulted in the sudden erosion of underlying clay beds, the lumps of which were transported only short distances, probably by torrential currents.

The best exposure of the breccia in Union County is 3 miles southwest of Myrtle along an abandoned east-west road on a west-facing slope (Center, Sec. 26, T.6 S., R.1 E.) where abundant fragments, a few 4 feet in size in a red sand matrix, are exposed over a 50-foot interval. Other exposures are at the following places: (1) a quarter of a mile east of Myrtle Tower along the east-west road (NE. Cor., Sec. 11, T.6 S., R.1 E.); (2) 2 miles west of Myrtle along a dirt road (N. edge, Sec. 13, T.6 S., R.1 E.); (3) 1 1/2 miles northeast of Darden (Center, Sec. 34, T.6 S., R.1 E.) along a gravel road where a cut on the west-facing slope exposes an irregular 3-foot or 4-foot bed of breccia about 6 or 8 feet above the Midway-Wilcox contact; and (4) about 1 mile west of Salem Church and a few hundred feet west of a northeast-southwest road (SE. 1/4, Sec. 32, T.7 S., R.1 E.) in some small creek channels. Good exposures of this breccia are also present in Tippah, Benton, and Pontotoc Counties.

At several places in the vicinity of Rocky Ford and Etta a massive white sandstone layer, ranging in thickness from 3 feet or less to about 10 feet, is found only a few feet above the Midway-Wilcox contact. It is so strongly cemented that it has been referred to at times as a quartzite. The most notable exposure of this quartzitic sandstone is on the ridge just east of Rocky Ford where Highway 30 winds conspicuously along the divide between the steep-sided gullies in which the ledges and large boulders of rock are conspicuous. This rock may be a consolidated phase of a white sand which is seen nearby at this horizon or close to it and which is mentioned again in the section on Economic geology.

In many places large or small areas of the sand have escaped erosion, due chiefly to their accidental situations between drainage lines, so that many sand-capped hills and ridges rise from the otherwise nearly level Flatwoods (Fig. 2). The geologic map (Pl. I) shows 20 such Wilcox outliers in Union County. One of these, crossed by Highway 30 southwest of Union School (Sec. 16, T.7 S., R.2 E.), is of interest, because of the apparent abnormal position of the Midway-Wilcox contact. Just south of Highway 30, along a north-south road stratified sand rests on the Porters Creek clay only a few feet above the Tallahatchie floodplain level, while a mile to the west are Porters Creek exposures about 50 feet higher, suggesting that the contact has a reversal in dip. It is entirely possible, however, that this outlier, which exhibits a thickness of about 65 feet of sand, is reworked terrace material, or it may be, as suggested by Monroe[44], a remnant of a fan deposit formed by sand washed out over the Flatwoods from the adjacent Wilcox hills. The presence of petrified wood fragments in the basal portion, however, suggests that these are true basal Ackerman beds, as does a quartzite pebble found in place just above the contact by Glen F. Brown of the U. S. Geological Survey, while visiting the place with the writer. The soil on the higher slopes, however, although poorly exposed, does not look altogether like typical Ackerman sand soil. The possible significance of this interesting outlier is discussed further in the section on Structural geology.

West of the Flatwoods, the Ackerman sand has been deeply eroded so that its outcrop belt is a region of irregular hills which form the easternmost portion of the North Central Hills. So far as is known all the hills in the western part of Union County are capped by Ackerman sand.

Above the Ackerman sand are interbedded laminated clays and sands which constitute the typical Ackerman. No exposures of these are known in Union County, though they are found a few miles to the west in Marshall and Lafayette Counties.

POST-EOCENE DEPOSITS

PLIOCENE OR PLEISTOCENE STREAM TERRACES

In some parts of Mississippi are important river terraces much younger than the underlying strata previously described. Shaw[45] suggests that they are of Pliocene age. Little attention was given to terraces in Union County although they were noted at several places. Along most of the major drainage lines are, above the present day floodplains, "second bottoms," remnants of earlier floodplains at higher levels.

In the southeastern part of the county conspicuous sandy terraces are present in many places at the edges of the floodplains of the various headwater streams of the Tombigbee drainage.

In the western part of the county, about 1 mile west of Enterprise a small cut for Highway 30 at the edge of the Flatwoods exposes some poorly stratified red clayey sand which, however, is considerably lower than the Porters Creek-Ackerman contact, and is interpreted as a terrace deposit. The previously mentioned supposed outlier of Ackerman sand (Sec. 16, T.7 S., R.2 E.) may be of similar origin.

PLEISTOCENE AND RECENT

FLOODPLAIN ALLUVIUM

After a main stream has cut its valley as deeply as conditions will permit, the more rapidly flowing tributaries tend to bring more sediment to that stream than it can transport. In times of flood this excess clay, silt, or sand is spread in thin layers over the valley forming almost level surfaces popularly known as "bottoms," technically as floodplains. Except for a few streams in the Selma chalk area of the eastern part of the county, such floodplain alluvium is found along the courses of all the main streams in Union County and even extends nearly to the heads of some of the tributaries. Where well exposed, as in artificially dug channels or recently eroded tributaries, it typically consists of light-bluish or grayish clayey material containing abundant plant remains, overlain by a few feet of coarser silt and sand.

The lower material probably accumulated slowly over a long period of time before the coming of the white man, when forested slopes permitted only a minium of erosion, and when the "bottoms" contained heavy growths of cane and hardwoods. The coarser upper stratum probably represents the silting up of the "bottoms," due to the greatly accelerated rate of erosion consequent on the cutting of the forests and the plowing of the land since the white man's occupation. The age of the lower material has been demonstrated recently by the discovery of bones of an extinct mastodon in similar material in Tippah County[46]. The very recent age of the upper material is convincingly demonstrated in Union County on the Arthur Rogers property 1 1/4 miles west of New Albany (NW. 1/4, Sec. 7, T.7 S., R.3 E.). An old wooden bridge on an abandoned road across a small tributary of the Tallahatchie is buried beneath 4 or 5 feet of typical floodplain sandy clayey silt. The bridge is said to have been abandoned 25 or 30 years ago (probably about 1910 or 1915).

COLLUVIUM

Rainwash, landslips, and other less important processes cause a slow downward migration of surface material, so that in many places the hill slopes are mantled with material which has moved downward as much as 100 feet or more from its original position. Such migration, however, except in the case of landslips, destroys any stratification which the material may have originally possessed. This process is particularly effective where sand beds overlie clay. In Union County, it is most pronounced along the Porters Creek-Ackerman contact, where special caution must be exercised in mapping, for the colluvial Ackerman sand customarily veneers the surface for many tens of feet below the contact. In such locations no assurance can be felt that sand is in place unless it shows distinct stratification, and even there large-scale landslipping may cause confusion if its presence is not recognized.

STRUCTURAL GEOLOGY

The Cretaceous and Paleocene strata strike almost due north and south, and dip gently westward about 30 feet to the mile (Fig. 2). The younger Ackerman (Eocene) formation which lies unconformably on the older strata appears to have a westward dip of about 10 to 15 feet a mile. As all determinations of elevation were made with an altimeter, a little uncertainty regarding them exists, though in no case is the degree of uncertainty believed to be significant. A few irregularities in these dips are noted.

Accurate determination of dips is difficult chiefly because of the paucity of recognizable horizons, partly because of uncertainties introduced by unconformities, and partly because of the scarcity of outcrops in some areas.

The upper and lower contacts of the Prairie Bluff formation and the Midway-Wilcox (Porters Creek-Ackerman) contact were used as key horizons. The Prairie Bluff has been assumed, for this purpose, to have a uniform thickness of 40 feet, and even though both contacts are unconformities, any irregularities on this account are deemed to be of little importance in view of the thinness of the bed. In using this formation it is important to find either its upper or lower contact—Clayton or Ripley limestone, respectively—in order to be sure that one is not dealing with some lithologically similar unit in the Ripley formation.

The Prairie Bluff contacts were traced over a 6 mile-wide belt from the north to the south edge of the county, and throughout this area nearly all readings were closely consistent with a 30-foot dip. The most notable conclusion drawn from observations on this horizon is that an anticline of some magnitude is not indicated in the region around Wallerville as was once supposed. Some years ago it was noted that outcrops of the Prairie Bluff in the Frisco Railway cuts increase regularly in elevation from New Albany to Wallerville, and that a lithologically similar material was exposed in the "blue cut," 2 1/2 miles farther east at a much lower elevation. The crest of an anticline was thus assumed to be located near Wallerville on which an unsuccessful well was drilled (NW. 1/4, Sec. 36, T.7 S., R.3 E.). Many unfortunate citizens of Union County invested heavily of their savings in the venture.

It now seems certain that the "blue cut" outcrop is of a blue somewhat fossiliferous marl in the lower member of the Ripley Formation. Present work on the ridge just north of Wallerville, as well as on scattered Prairie Bluff outliers east and southeast of Wallerville, suggests that though there may be a slight flattening of the dip for 2 or 3 miles east of Wallerville, there is no pronounced reverse dip of the magnitude once supposed. Between Wallerville and New Albany, the Prairie Bluff-Clayton contact seems to dip about 40 feet a mile.

The Midway-Wilcox contact, an unconformity, is an unreliable horizon, but it is the only recognizable one known in the western third or more of the county. Since the Porters Creek clay today forms the Flatwoods area of little relief, one might assume that a similar topography developed on it during the Midway-Wilcox interval. At most of its exposures the elevation of the contact has been determined approximately, and, with one possible exception, it appears to dip west about 10 or 15 feet a mile with only minor irregularities. The one exception is the Union outlier (Sec. 16, T.7 S., R.2 E.) 6 miles west of New Albany.

An apparently good Midway-Wilcox contact beside a north-south road at the south end of the outlier is about 40 feet lower than outcrops of Porters Creek clay on the highway a mile to the west. Poor exposures along the north-south road half a mile farther north (NW. 1/4, Sec. 17, T.7 S., R.2 E.) indicate that the contact may be at least another 15 feet higher, thereby suggesting a total reverse dip of about 55 feet. A check on this possibility, however, on the few outliers to the north, suggests that an approximately normal dip prevails in that region. It is also possible that the Tallahatchie, just north of New Albany, follows a small fault which extends north of the Union outlier, causing this outlier to be lower than the other nearby outliers. No evidence has been found for such a fault, however, and it seems safer to assume that the Union "outlier" is of terrace or fan origin, of more recent date.

In the northeastern part of the county, the McNairy sand seems to rise to the east to a point beyond the Prentiss County line at a fairly uniform rate.

Two other features of possible structural significance have been noted in Union County. The Naheola, or laminated upper phase of the Porters Creek formation, exhibits some abnormal southwesterly dips of 2 to 8 degrees over a distance of several hundred yards in the creek bed 1 mile south of Salem Church (Center, Sec. 4, T.8 S., R.1 E.) while less marked dips in the same direction are present in the creek bed half a mile northwest (NE. Cor., Sec. 5). These dips may represent a pre-Wilcox deformation.

The other suggestive feature is the presence of several asymmetric north-south valleys whose steep east walls not only contrast strikingly with their west walls, but are on the opposite sides of the valleys from the ones where they would be expected if the strata were dipping westward. Notable instances of these are the valleys of the following creeks: (1) Pinhook, (2) Cane, (3) Little Mud (Ayres), and (4) Locke. In the case of Pinhook, however, cross-valley correlation of the Prairie Bluff suggests a normal westward dip.

In brief, no apparently significant surface evidence has been found in Union County of important structural irregularities. It is believed that the mapping has been done in sufficient detail so that any such structures would have been detected.

It is entirely possible, of course, that the deeply buried older strata, separated by unconformities from the overlying materials, may possess structures suitable for oil and gas accumulation. Such buried structures, however, could be detected only by highly trained operators using delicate geophysical apparatus.

ECONOMIC GEOLOGY

The chief mineral resource of Union County appears to be various kinds of clays. Less promising are deposits of bauxite, bentonite, siderite, sand, and marl. No good surface indications of structures favorable for oil and gas accumulation were found.

CLAYS

The high-grade clays of Union County are found at the contact of the Midway and Wilcox series, in the western part of the county. Both kaolin and bauxite were probably formed by weathering long ago of some portion of the Porters Creek clay. To these materials Mellen has applied the term Betheden formation, and although that term is not used in the stratigraphic section of this report, it is here used for convenience. These clays, typically a few feet thick, probably once formed a more or less continuous blanket, much of which was subsequently eroded. They grade downward into more micaceous and silty material which in turn becomes yellowish and grades into the Naheola type of Porters Creek clay. In Tippah County[47] a pottery clay appears to intervene below the kaolin, but the samples show no such material in Union County. Such material, if present in a few places, may have been overlooked, however, for in auger samples it closely resembles Porters Creek clay, at which depth sampling was discontinued. Not until field work was completed was its true nature discovered in the laboratory which ran routine tests on a few samples from Tippah County. In Union County it is probably not important.

Above the bauxite-kaolin zone are local deposits of the Fearn Springs clays which are believed to have been produced by the reworking and depositing of the kaolinitic clays. The Fearn Springs clays are well suited to many purposes.

SURFACE CLAYS

Surface clays, including both weathered residue and alluvial material, are used for brick at many places in Mississippi. In the hope that the abundant and accessible surface clays in Union County might likewise prove suitable for brick, tile, or other heavy-body products, many samples were taken near the railroad lines, but the report of the ceramic engineer does not bear out this hope.

FEARN SPRINGS CLAYS

Fearn Springs plastic clays are present in considerable abundance in the northwestern part of Union County near Myrtle. Included in this group are some plastic clays above the Fearn Springs sand, and others below the Fearn Springs sand but above the Betheden or Porters Creek clays.

In the hills west of the Frisco Railway such clays are probably present in appreciable quantities, but because of their location it did not seem worthwhile to investigate them. On the Benton County line, and just north of it, some 2 1/2 miles north of Myrtle, are exposures of plastic clays along old U. S. Highway 78. These are so close to the Frisco Railway line, and to Union County, that samples of them were taken. No attempts were made to block out acreages of these clays, but it seems reasonably certain, on the basis of scattered exposures, a few drill holes, and the topography, that a few tens of acres are underlain by 10 to 20 feet of this clay, having an overburden of only soil or perhaps a few feet of other clay or sand. Conservative estimates indicate that there may be here well over

200,000 tons of such clay within a few hundred yards of the Union County line and the Frisco Railway, in a section of practically no houses and within 1 or 2 miles of a TVA power line.

About three-quarters of a mile farther east, and just north of the line, in Benton County, several auger holes (D21-26) penetrated from 12 to 25 feet of these clays. Unfortunately, the topography here is rugged, a sand overburden in many places might be prohibitive, and the region is a mile from easy access to the railroad. These clays, however, overlie, at least in part, kaolinitic clays, and it is conceivable that the two types might be developed jointly.

In southwestern Union County, near Pinedale, Fearn Springs clays are present locally above the Betheden clays. Samples were taken from the properties of H. S. Gafford (D87, D113), O. D. Gray (D98, D186), and the Holly Springs National Forest (D164, D171). These, too, where present, overlie Betheden clays.

BETHEDEN CLAYS

The Betheden clays are characteristically white or nearly white, kaolinitic or bauxitic in nature, and commonly highly aluminous. They are known in only one part of Union County, near Pinedale, but are also present on the Union-Benton line, and about 1 1/4 miles farther north of the line on and near the property of L. V. Fowler. Though beyond the bounds of Union County, they were prospected partly in the vain hope that they could be traced back into Union County, and partly in the belief that a development of these clays would benefit Union County.

PINEDALE REGION

In 1923 Morse[48] reported white clays under bauxite at the L. B. Busby place (Sec. 33, T.7 S., R.1 E.); more recently Miss Alta Ray Gault recognized kaolinitic clay in a well on the C. H. Simmons place (Sec. 10, T.8 S., R.1 E.); and while these clays were being sampled Mr. O. D. Gray reported similar clays on his property (Sec. 4, T.8 S., R.1 E.). These three places, together with several other outcrops in the vicinity, suggest a bed of bauxitic kaolin extending with interruptions over a distance of 2 1/2 miles. As a result of many auger holes in this region it appears that there is a fairly persistent bed of highly aluminous white clay. In some places, however, the belt is broken

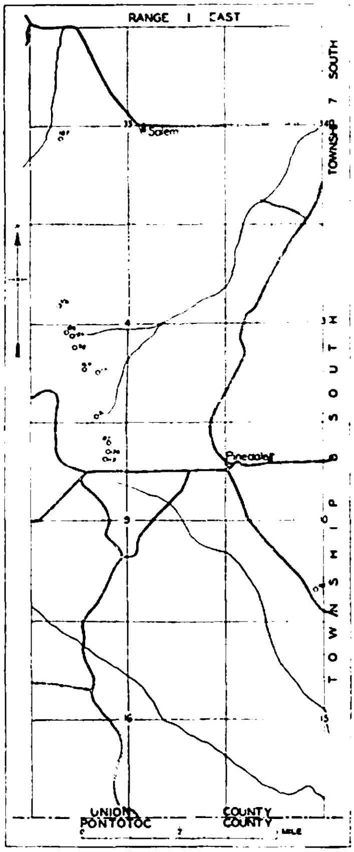

Figure 11.—Map of the Pinedale Region, showing the locations of test holes.

by present valleys, but on and near the property of O. D. Gray it seems to have its best development. Samples were tested from the following properties: O. D. Gray (D98, D128, D137, D186), H. S. Gafford (D87), C. L. Hearn (D156), C. H. Simmons (D101), and Holly Springs National Forest (D91, D164, D171, D187). Where it is thickest, the purer kaolinitic clay is about 10 feet thick and grades downward into less pure silty and micaceous material.

It is not possible, on the basis of scattered auger holes, to state probable tonnages of the purer portions, though it is almost certain that there are many tens of acres where the overburden would not exceed 10 or 20 feet of clay and sand, so it would seem that at least several hundred thousand tons of the material are present, and the accessible quantity might equal or exceed 1,000,000 tons.

These clays should be further explored if a demand for large quantities of high-alumina clay ever arises.

L. V. FOWLER REGION

About 1 1/4 miles north of the Union-Benton County line are several exposures of kaolinitic clay on and near the property of L. V. Fowler (SE. 1/4, Sec. 30, T.5 S., R.2 E.). A small north-flowing

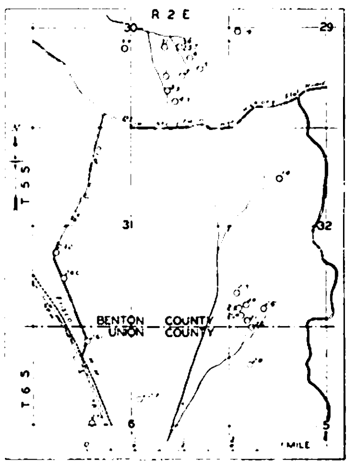

Figure 12.—Map of the L. V. Fowler region, showing the locations of test holes.

tributary of Oklimata Creek affords the best exposures, and several auger holes along its valley show a fairly persistent bed of high-alumina clay having a thickness up to 16 feet (D33, D34, D257). Most of the prospecting was east of the outcrops, where some 40 acres seem to be underlain by this clay, though in some places the overburden is 50 feet thick. West of these exposures the same clay probably underlies many more acres.

On the county line, 1 1/4 miles south of the Fowler outcrops, and 1 mile east of the Frisco Railway track, a small stream ditch (SW. 1/4, SW. 1/4, Sec. 32, T.5 S., R.2 E.) affords another outcrop of kaolinitic clay. Between this outcrop and those on the Fowler property, the land is somewhat higher, and is hilly and wooded, but it is altogether probable that more of the clay underlies this area. One test hole (D14) in this area was not deep enough to encounter the kaolin.

About 1 1/4 miles east of the Fowler outcrops bauxitic kaolin is found near the road (SE. 1/4, Sec. 29, T.5 S., R.2 E.). A test pit here (D270) revealed 9 feet of highly-aluminous clay. This exposure is separated from the Fowler and county line exposures by hilly country which may well be underlain by the clay.

Figure 13.—Sampling clay in an 8-inch hole in the bottom of a 4-foot pit. L. V. Fowler property.—June, 1939.

It is evident that a thick layer of bauxitic kaolin is here present, and it is reasonably certain that the clay underlies several tens of acres. If this be the case there must be well over 100,000 tons of the clay in sight. If it can be demonstrated that such a bed is reasonably continuous from the Fowler area to the county line and the site of hole D270, then there may be upwards of a square mile of the clay, the quantity of which would be at least several millions of tons.

If a demand for high-alumina clays ever develops, it would seem that this is one of the most promising localities in Mississippi. In addition to the probable extensive deposit in the Fowler region this area is only about 3 miles from the Flat Rock Church exposures of similar clays, described recently in a report on Tippah County,[49] and the intervening area offers promise of more discoveries, which might well multiply the above estimates several times.

BAUXITE

Inasmuch as the bauxite deposits of Union County were thoroughly prospected in 1922 and the report on those findings is available in published form[50], it has not seemed advisable in this survey to duplicate that work. Since then, one other deposit has been reported from the land of John H. Carnal (NW. 1/4, Sec. 9, T.7 S., R.1 E.) by Burchard[32] who had no opportunity to investigate the deposit. During the present survey a pit was dug at the top of the small gently-sloping hill around which the bauxite crops out, but it revealed only 4 feet of white sandy bauxite which is clearly re-worked material as it is separated from the underlying Porters Creek clay by 18 feet of Wilcox sand and clay. The bauxite bed underlies only 1 acre, and can hardly be of commercial value.

PORTERS CREEK CLAY

Unlimited quantities of Porters Creek clay are available in Union County for any conceivable use to which it might be suited. Because of its great extent, its unusual nature, and its nearly uniform character, many experiments have been conducted on it. In Tennessee, Whitlatch[51] has reported it suitable for making light-weight brick and for use as a bleaching clay. Recently Dunbeck[52] patented the use of Porters Creek clay, along with some other clays, as a bond in preparing foundry molds. More recently McCutcheon[53] has found it apparently well suited for rotary drilling mud in salt water beds, and admirably suited as a burned light-weight aggregate for concrete.

At several places in Union County the clay is abundantly exposed and accessible for large-scale production if a demand for it ever develops. Among such places are: (1) the C. J. Myers place (SW. 1/4, Sec. 24, T.6 S., R.1 E.) where a 50-foot bluff (Fig. 7) on the southwest bank of a stream has very little overburden; (2) around a small Wilcox outlier traversed by U. S. Highway 78 about 1 mile south of Myrtle (Sec. 20, T.6 S., R.2 E.); (3) in several places about 6 miles west northwest of New Albany (Secs. 33 and 34, T.6 S., R.2 E., and Sec. 3, T.7 S., R.2 E.) where it is exposed around outliers of Wilcox sand; (4) along the roads about 5 miles north northwest of New Albany (Secs. 7, 12, 13, 18, and 24, T.6 S., Rs.2 and 3 E.); (5) on both sides of Highway 30, 4 miles west of New Albany (Sec. 10, T.7 S., R.2 E.); and (6) 2 1/2 miles northwest of the Gulf, Mobile & Ohio Railroad station at Ingomar (Secs. 34, 35, T.7 S., R.2 E.).

At the first three of these localities the typical dark massive phase is exposed; at the last three the lower, more bentonitic phase is exposed. Many other exposures of the clay are present in the county, but the ones mentioned are all reasonably close to good roads and a railroad.

BENTONITE

Bentonite is a clay which, when suitably prepared, possesses many unusual properties such as the ability of bleaching mineral and vegetable oils. It is probably an altered volcanic ash which fell into the sea, possibly at a considerable distance from its source. Typically it has a waxy appearance, cracks badly on drying, and may be any one of many colors. Such clays have been found during recent years in many parts of the country and have been known in Mississippi since 1927[54]. Since that time three bulletins on Mississippi bentonite have been published[55 56 57].

In his investigation Bay collected three samples of Porters Creek clay from Union County, but tests indicated that none of these was of commercial grade.

As has been noted in the stratigraphic section of this report, the lower part, 50 feet more or less, of the Porters Creek clay appears more bentonitic than does the rest of the formation, and a similar basal phase has been previously noted[58] in Tippah County. Abundant exposures of this material, on the west wall of Hell Creek 4 miles west of New Albany, reveal many acres of this clay having only a thin overburden of soil. Other exposures of it are listed in the preceding section on the Porters Creek clay (localities 4 and 6).

A bed of purer bentonite was discovered recently in Pontotoc County by Mellen between layers of upper Ripley limestone. Subsequent search for it in Union County by Vestal[59] and Mellen was unsuccessful, as were further searches during the present survey, though it is entirely possible that some future road cut, well, or other excavation at that stratigraphic position will reveal its presence in Union County. Commercial extraction of the Pontotoc County bentonite began in 1939.

SIDERITE

Iron carbonate, locally termed "paint rock" and technically called siderite, has been worked in nearby portions of Benton County both as paint pigment and as manganiferous iron ore. Lowe[60] has described some in the northwestern part of Union County (Secs. 5 and 6, T.6 S., R.1 E.). No other promising deposits of this material are known in this region, and at present siderite in such thin and sporadic deposits is of little economic value. This material is in the Fearn Springs formation.

Near Pinedale abundant concretions of siderite are found in the laminated Porters Creek clay (probably Naheola material). The most abundant ones were seen on the O. D. Gray property (NE. 1/4, Sec. 4, T.8 S., R.1 E.) where they are present in a creek bed, and about three-quarters of a mile southeast of the Pinedale Crossroads where they too are found in a creek bed (Sec. 10, T.8 S., R.1 E.).

SANDS

Red Wilcox sand caps many small hills in the Flatwoods area, and is used locally in the improvement of county roads. The two chief pits are 5 miles west northwest of New Albany, and at Enterprise (SW. Cor., Sec. 34, T.6 S., R.2 E., and Sec. 13, T.7 S., R.1 E.). Abundant deposits of the sand are present in the western part of the county (Pl. I).

White sand has been found locally near the base of the Ackerman formation, and a careful watch was kept for more of it. The only deposit, however, which appears at all promising is about half a mile north of the Rocky Ford Bridge (SW. 1/4, Sec. 8, T.7 S., R.1 E.) on the land of A. F. Rhea and F. L. Ford. White sand has been dug here from time to time for local use in plaster or mortar. A few test holes in the vicinity revealed a bed of irregular thickness up to about 20 feet, but apparently with a horizontal extent of a few hundred feet at the most. Within the white sand are scattered thin layers of yellow and light-red sand. At this place the sand appears to lie directly above the Porters Creek clay, and is overlain by many feet of red sand. Nearby ledges and boulders of massive white sandstone probably represent consolidated portions of this same material.

Some fine-grained white sand was dug from a well on the Union-Pontotoc County line on the property of C. H. Thomas (NW. 1/4, Sec. 23, T.8 S., R.1 E.) but some nearby auger holes failed to reveal important amounts of it. No other deposits of white sand suitable for glass manufacture were found in Union County, though some future well or excavation might reveal it.

MARLS, CHALKS, AND CALCAREOUS CLAYS

Abundant marls, chalks, and calcareous clays are present in Union County, having a wide range of compositions, so that it has seemed worthwhile to sample and test some of them with a view to their utilization in the manufacture of rock wool, or that information regarding them might be available in case future industries require such material in the manufacture of products today unknown.

Three stratigraphic levels in Union County of such materials are: (1) the transitional clay at the base of the Ripley formation; (2) the lower Ripley marl layers; and (3) the Prairie Bluff formation.

As was pointed out in the Stratigraphic section of this report, a 50-foot transitional zone between the Selma chalk and the Ripley formation is essentially a slightly sandy, calcareous clay. Good exposures of this clay are present both north and west of Sherman (Sec. 12, T.8 S., R.4 E.) where several samples were taken, and where several acres have only a thin soil overburden. In the "Tests" section of this report, these materials are stated to be too low in lime to be of value as rock wool material. Nearby, however, are abundant exposures of Selma chalk, and it may well be that these materials could be combined to afford the necessary composition for rock wool.

Samples of the Prairie Bluff impure chalk were taken from a new cut for Highway 15 beside the Gulf, Mobile & Ohio Railroad about 6 miles north of New Albany (NE. 1/4, Sec. 16, T.6 S., R.3 E.) and from a cut, also for Highway 15, about 3 miles south of New Albany on the south wall of King Creek (NW. 1/4, Sec. 29, T.7 S., R.3 E.). Large quantities of this material having a small amount of overburden could probably be obtained close to the Gulf, Mobile & Ohio Railroad either at the first of these localities or about 2 1/2 miles south of New Albany (Center, Sec. 19, T.7 S., R.3 E.), not far from the second sampled locality (King Creek).

The lower Ripley marl was not sampled, but probably resembles the Prairie Bluff more than it does the lower Ripley clay.

TEST HOLE RECORDS

In the several pages which follow there are reproduced the records (logs) of those test holes from which samples were tested in the laboratory. Many other exploratory holes were drilled with the aim of finding other worthwhile deposits or of tracing those already known, but it does not seem worthwhile to reproduce them here. Records of those other test holes are on file at the office of the Mississippi Geological Survey.

In most instances small metal tags bearing the numbers of the holes were tacked to nearby trees. The prefix "D" was added to all Union County test hole records and samples to distinguish them in the laboratory from samples collected in other counties in the state.

L. V. Fowler Property

Test Hole D1

Location: T.5 S., R.2 E., Sec. 30, SE.1/4 of NW.1/4 of SE.1/4 (Benton County), about 100 ft. east of a small creek and 11 ft. above a prospected clay outcrop Drilled: Oct. 3-5, 1938
Elevation: 18.3 ft. above floodplain Water level: 17.7 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	3.6	3.6	Soil and subsoil, red clay and sand
			Fearn Springs
2	4.4	0.8	Clay, yellowish-gray arenaceous, micaceous plastic
3	8.4	4.0	Clay, gray silty slightly micaceous plastic; C1
4	9.0	0.6	Clay, yellow micaceous very silty; a few lumps of gray clay
			Midway
5	11.0	2.0	Clay, gray silty micaceous; C2
6	15.5	4.5	Clay, gray silty micaceous; C3
7	17.7	2.2	Clay, bluish-gray; very little silt; semi-plastic; C4
8	19.1	1.4	Clay, white plastic; C5
9	26.0	6.9	Clay, white semi-plastic; increasingly silty; a few lignitic streaks; C6
10	26.7	0.7	Rock; probably siderite; in clay like No. 9; C7
11	31.7	5.0	Clay, white highly silty micaceous semi-plastic; C8
12	36.6	4.9	Clay, bluish-gray silty highly micaceous; probably Porters Creek clay

Remarks: Sample C1-2 discarded as a defective sample.

L. V. Fowler Property

Test Hole D3

Location: T.5 S., R.2 E., Sec. 30, SW. 1/4 of NE. 1/4 of SE. 1/4 (Benton County), 400 ft. due east of hole D1, in a cotton field Drilled: Oct. 3-29, 1938
Elevation: About 38 ft. above D1 (and about 520 ft. above sea level)
Water level: 42 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	3.3	3.3	Soil and subsoil, gray
			Fearn Springs
2	4.9	1.6	Rocky material
3	12.2	7.3	Sand, red micaceous, argillaceous; some yellow streaks
4	23.8	11.6	Sand, yellow medium-fine to coarse
5	24.3	0.5	Sand, red medium-fine to coarse; a few ferruginous rocks
6	36.0	11.7	Sand, yellowish-red fine-grained to coarse
7	37.2	1.2	Clay, dark-brown; some lignitic material; C1
8	40.0	2.8	Clay, dark-gray slightly silty plastic; C2
9	44.0	4.0	Clay, white; very little silt; a few lignitic streaks; C3
			Midway?
10	45.5	1.5	Clay, gray micaceous silty
11	48.0	2.5	Clay, dark-gray silty micaceous
12	52.0	4.0	Clay, white slightly plastic; some lignitic streaks
13	56.0	4.0	Clay, dark-gray slightly silty

Remarks: C1 discarded as worthless. Hole abandoned on account of caving.

L. V. Fowler Property

Test Hole D5

Location: T.5 S., R.2 E., Sec. 30, NE. 1/4 of SE. 1/4 (Benton County), about 485 ft. N. 65° E. of hole D3 Drilled: Oct. 5-14, 1938
Elevation: About the same as D1 Water level: 14.9 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	5.1	5.1	Soil and subsoil, red sandy
			Midway
2	14.9	9.8	Clay, light-yellow very silty
3	16.8	1.9	Clay, dark-gray micaceous plastic; dark-brown streaks
4	19.9	3.1	Clay, grayish slightly micaceous
5	22.9	3.0	Clay, black lignitic; C1
6	23.8	0.9	Clay, white; free from grit and mica; C2
7	44.5	20.7	Clay, dark-gray highly micaceous silty; C3
8	45.0	0.5	Clay, dark-blue micaceous silty; probably Porters Creek clay

Remarks: C1 discarded as worthless.

L. V. FOWLER PROPERTY

TEST HOLE D6

Location: T.5 S., R.2 E., Sec. 30, NE. 1/4 of SE. 1/4 (Benton County), about 700 ft. N. 15° E. of hole D3 Drilled: Oct. 11-14, 1938
Elevation: About 20 ft. below D3 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	5.4	5.4	Soil and subsoil
			Midway
2	7.8	2.4	Clay, dark-gray; pisolitic streaks; C1
3	8.6	0.8	Clay, brown pisolitic; C2
4	9.7	1.1	Clay, light-gray pisolitic slightly plastic; C3
5	14.6	4.9	Clay, light-gray pisolitic; C4
6	19.3	4.7	Clay, light-gray mottled; some yellow streaks; C5
7	20.3	1.0	Clay, bluish-gray; yellow streaks; C6
8	21.7	1.4	Clay, light-gray silty; brown streaks; C7
9	24.9	3.2	Clay, light-gray slightly silty; C8
10	28.4	3.5	Clay, gray silty micaceous; C9
11	28.9	0.5	Clay, light-gray micaceous
12	30.2	1.3	Clay, Porters Creek

Remarks: C1-2 discarded as worthless.

L. V. FOWLER PROPERTY

TEST HOLE D9

Location: T.5 S., R.2 E., Sec. 29, NW. 1/4 of SW. 1/4 (Benton County), about 1500 ft. N. 60° E. of hole D6, and about 265 ft. S. 65° E. of NW. corner of SW. 1/4, Sec. 29 Drilled: Oct. 13-14, 1938
Elevation: Near floodplain Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	5.3	5.3	Soil and subsoil, gray and yellow clay
			Fearn Springs
2	6.6	1.3	Clay, light-brown silty lignitic; white streaks; C1
3	10.6	4.0	Clay, white silty semi-plastic; C2
4	13.5	2.9	Clay, yellowish-gray silty; lignitic streaks; C3
			Midway
5	15.5	2.0	Clay, gray micaceous; yellow streaks
6	16.8	1.3	Clay, dark-blue highly micaceous silty; probably Porters Creek clay

Remarks: Overlying material is laminated clay, probably Fearn Springs.

L. V. FOWLER ESTATE

TEST HOLE D14

Location: T.5 S., R.2 E., Sec. 32, SW. 1/4 of NW. 1/4 (Benton County), 220 ft. S. 15° W. of a log crib — Drilled: Oct. 17-26, 1938

Elevation: 7.5 ft. above floodplain — Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	1.5	1.5	Soil and subsoil
			Fearn Springs
2	2.2	0.7	Clay, gray slightly silty
3	8.1	5.9	Clay, brown highly silty; C1
4	10.0	1.9	Clay, gray slightly silty; yellow streaks; C2
5	11.4	1.4	Clay, gray; yellow and red streaks; C3
6	12.3	0.9	Clay, yellow slightly silty plastic; red, gray, and lignitic streaks; C4
7	16.7	4.4	Clay, brown; lignitic streaks; C5
8	18.1	1.4	Clay, yellow; white streaks; a few lignitic streaks; C6
9	22.0	3.9	Clay, white slightly silty and micaceous; C7
10	24.5	2.5	Clay, dark-gray highly silty slightly plastic; possibly Porters Creek clay

L. V. FOWLER ESTATE

TEST HOLE D20

Location: T.5 S., R.2 E., Sec. 32, SW. 1/4 of SW. 1/4 (Benton County), 75 ft. north of Union County line and about 4550 ft. east of old U. S. Highway 78 at the county line — Drilled Oct. 27-Nov. 1, 1938

Elevation: About 435 ft. above sea level — Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	3.6	3.6	Soil and subsoil, sandy
			Fearn Springs
2	5.5	1.9	Clay, yellow slightly silty; some pebbles; C1
3	6.7	1.2	Clay, red highly silty slightly micaceous; C2
4	7.4	0.7	Clay, gray slightly micaceous; red and lignitic streaks; C3
			Midway
5	11.7	4.3	Clay, brown slightly micaceous semi-plastic; probably pisolitic; gray streaks; C4
6	13.1	1.4	Clay, white slightly micaceous and silty; C5
7	18.0	4.9	Clay, white slightly micaceous and silty plastic; yellow and lignitic streaks; C6
8	20.0	2.0	Clay, dark highly micaceous silty; probably Porters Creek clay

Remarks: Hole is 17 feet above outcrop of white clay in ditch. C1-2 discarded as worthless.

L. V. FOWLER ESTATE

TEST HOLE D21

Location: T.5 S., R.2 E., Sec. 32, SW. 1/4 of SW. 1/4 of SW. 1/4 (Benton County), 190 ft. N. 35° W. of hole D20 Drilled: Oct. 27-Nov. 2, 1938
Elevation: 2.5 ft. above D20 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	3.5	3.5	Soil and subsoil, yellow sand
			Fearn Springs
2	7.2	3.7	Clay, yellow; gray streaks; C1
3	8.6	1.4	Clay, light-brown silty slightly micaceous; C2
4	14.3	5.7	Clay, yellow; white and lignitic streaks; C3
5	16.0	1.7	Clay, white silty; yellow streaks; C4
6	18.3	2.3	Clay, white silty micaceous; C5
7	22.5	4.2	Clay, gray silty micaceous; yellow streaks; C6
			Midway
8	23.6	1.1	Clay, dark-brown very silty micaceous; probably Porters Creek clay

Remarks: C1-2 discarded.

L. V. FOWLER ESTATE

TEST HOLE D22

Location: T.5 S., R.2 E., Sec. 32, SW. 1/4 of SW. 1/4 of SW. 1/4 (Benton County), 222 ft. N. 47° W. of hole D21 Drilled: Oct 28-Nov. 23, 1938
Elevation: 15 ft. above D21 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	6.6	6.6	Soil and subsoil, red clay and sand
			Fearn Springs
2	10.6	4.0	Clay, brown very silty slightly micaceous; white and lignitic streaks; C1
3	13.1	2.5	Clay, yellowish-gray slightly micaceous very silty plastic; white streaks; C2
4	17.1	4.0	Clay, dark-gray silty slightly micaceous plastic; brown streaks; C3
5	17.5	0.4	Clay, dark-brown silty slightly micaceous plastic; lignitic streaks; C4
6	18.8	1.3	Lignite; C5
7	21.0	2.2	Clay, gray silty slightly micaceous plastic; brown streaks; C6
8	21.7	0.7	Clay, dark-gray silty slightly micaceous plastic; lignitic streaks; C7
			Midway
9	30.6	8.9	Clay, light-gray silty slightly micaceous; lignitic streaks; C8
10	33.3	2.7	Clay, white slightly micaceous silty plastic; few tiny lignitic streaks; C9
11	39.4	6.1	Clay, light-gray very silty slightly micaceous plastic; thin rock layer 33.3-33.8; C10
12	45.8	6.4	Clay, gray very silty slightly micaceous plastic; red and brown streaks; C11
13	47.5	1.7	Clay, Porters Creek

L. V. Fowler Estate

Test Hole D23

Location: T.5 S., R.2 E., Sec. 32, SW. 1/4 of SW. 1/4 (Benton County), 156 ft. N. 5° W. of D22 Drilled: Nov. 15, 1938
Elevation: 7 ft. above D22 Water level: 31.0 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	9.1	9.1	Soil and subsoil, red clay
			Fearn Springs
2	10.7	1.6	Clay, dark-gray silty highly plastic; brown streaks; C1
3	12.4	1.7	Clay, light-brown slightly silty; red and gray streaks
4	17.6	5.2	Clay, light-gray silty highly plastic; C2
5	18.4	0.8	Clay, light-brown highly silty plastic; yellow streaks; C3
6	19.4	1.0	Clay, light-gray slightly silty plastic; yellow streaks; C4
7	23.4	4.0	Clay, lignitic highly silty; C5
			Midway
8	27.6	4.2	Clay, gray highly silty; C6
9	31.8	4.2	Clay, light-gray; very little silt; C7
10	33.2	1.4	Clay, light-gray slightly silty plastic; C8
11	36.3	3.1	Clay, light-gray

Remarks: C1 discarded. Hole abandoned on account of caving.

L. V. Fowler Estate

Test Hole D24

Location: T.5 S., R.2 E., Sec. 32, SW. 1/4 of SW. 1/4 (Benton County), 147 ft. N. 75° E. of hole D23 Drilled: Oct. 31, 1938
Elevation: 2 ft. above D23 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	5.1	5.1	Soil and subsoil, red and brown sand clay
			Fearn Springs
2	7.7	2.6	Clay, dark-gray silty plastic; yellow streaks; C1
3	14.2	6.5	Clay, light-gray silty micaceous plastic; yellow streaks; C2
4	16.9	2.7	Clay, grayish-yellow slightly plastic; some coarse grit; C3
5	21.4	4.5	Clay, dark-gray silty micaceous plastic; (contaminated); C4
6	25.5	4.1	Clay, light-gray and yellow silty slightly plastic; C5
7	27.4	1.9	Lignite or lignitic clay; C6
			Midway?
8	36.0	8.6	Clay, light-gray silty micaceous slightly plastic; lignitic streaks; C7

Remarks: Thick series of light-colored silty clays in hills about a mile from highway and railroad. Hole abandoned on account of caving.

L. V. FOWLER ESTATE

TEST HOLE D25

Location: T.5 S., R.2 E., Sec. 32, NW. 1/4 of SW. 1/4 of SW. 1/4 (Benton County), 400 ft. N. 10° W. of hole D23 Drilled: Nov. 3-Dec. 3, 1938
Elevation: About 17 ft. below D23 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	2.2	2.2	Soil and subsoil
			Fearn Springs
2	3.7	1.5	Clay, gray silty laminated; red and yellow streaks; C1
3	5.3	1.6	Clay, dark-gray slightly silty laminated plastic; brown streaks; C2
4	7.3	2.0	Clay, dark silty micaceous; lignitic streaks; C3
5	12.2	4.9	Clay, light-gray silty plastic; brown streaks; C4
6	12.8	0.6	Clay, gray micaceous laminated; brown streaks; C5
7	13.3	0.5	Clay, brown somewhat lignitic; C6
8	15.6	2.3	Clay, white silty laminated; yellow and brown streaks; C7
9	16.3	0.7	Clay, gray silty somewhat lignitic; yellow streaks; C8
10	17.8	1.5	Clay, yellow silty plastic; gray streaks; C9
11	22.0	4.2	Clay, yellow laminated; gray, pink, and lignitic streaks; C9
12	23.5	1.5	Clay, gray slightly silty and micaceous; few yellow streaks; C10
13	24.4	0.9	Clay, gray slightly silty and micaceous; C11
14	26.5	2.1	Clay, gray laminated; lignitic streaks; slightly contaminated; C12
15	27.8	1.3	Clay, gray silty; slightly contaminated; C13
			Midway
16	28.4	0.6	Clay, yellowish-gray silty slightly micaceous
17	30.0	1.6	Clay, dark-gray; yellow streaks; probably Porters Creek clay

L. V. FOWLER PROPERTY

TEST HOLE D26

Location: T.5 S., R.2 E., Sec. 32, SW. 1/4 of SW. 1/4 (Benton County), 514 ft S. 85° E. of hole D24 Drilled: Nov. 15, 1938
Elevation: 13 ft. below D24 Water level: 21.7 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	4.8	4.8	Soil and subsoil, yellow silty clay
			Fearn Springs
2	8.8	4.0	Clay, gray silty plastic; yellow streaks; C1
3	13.3	4.5	Clay, light-gray plastic; yellow streaks; C2
4	14.6	1.3	Sand, red; streaks of gray clay; C3
5	15.6	1.0	Clay, gray silty lignitic micaceous plastic; yellow streaks; C4
6	21.7	6.1	Clay, white silty micaceous plastic; yellow streaks; C5
			Midway
7	23.5	1.8	Clay, gray highly micaceous silty; yellow streaks
8	24.4	0.9	Clay, dark-gray micaceous plastic; yellow streaks; probably Porters Creek clay

W. H. ROSS PROPERTY

TEST HOLE D28

Location: T.6 S., R.2 E., Sec. 5, NW. 1/4 of NW. 1/4, about 1100 ft. south of hole D20 Drilled: Nov. 3-28, 1938
Elevation: About 4 ft. below D20 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	4.1	4.1	Soil and subsoil, yellow sand
			Fearn Springs
2	6.7	2.6	Clay, gray silty; yellow streaks; C1
3	9.1	2.4	Clay, light-brown silty; gray streaks; C2
4	12.4	3.3	Clay, gray; yellow streaks; some silt; C3
5	14.3	1.9	Clay, brown silty micaceous pebbly; yellow streaks; C4
			Midway?
6	15.5	1.2	Clay, white slightly silty; yellow streaks; C5
7	21.7	6.2	Clay, white highly silty micaceous; C6
8	23.2	1.5	Clay, dark-blue silty micaceous; probably Porters Creek clay

L. V. FOWLER PROPERTY

TEST HOLE D31

Location: T.5 S., R.2 E., Sec. 30, NW. 1/4 of SE. 1/4 (Benton County), about 975 ft. north of hole D1 Drilled: Nov. 21-30, 1938
Elevation: About 7 ft. above D1 Water level: 27.0 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	12.5	12.5	Soil and subsoil, red
2	12.8	0.3	Sand, white
			Midway
3	13.3	0.5	Clay, brown highly micaceous silty semi-plastic; few yellow streaks; C1
4	16.3	3.0	Clay, white slightly micaceous silty plastic; yellow streaks; C2
5	22.4	6.1	Clay, yellow slightly micaceous and silty plastic; gray streaks; C3
6	31.4	9.0	Clay, light-gray highly micaceous increasingly silty plastic; yellow streaks; C4
7	32.7	1.3	Clay, dark highly micaceous silty; probably Porters Creek clay

L. V. FOWLER PROPERTY

TEST HOLE D33

Location: T.5 S., R.2 E., Sec. 30, NE. 1/4 of SW. 1/4 of SE. 1/4 (Benton County), 157 ft. south of hole D1 Drilled: Nov. 22-Dec. 1, 1938
Elevation: 7.5 ft. below D1 and 13.5 ft above bottom of stream ditch
Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	4.9	4.9	Soil and subsoil, grayish-yellow sand
			Midway
2	9.8	4.9	Clay, white slightly silty plastic; yellow-brown streaks; gradually becomes pisolitic commencing at 7.6; C1
3	15.1	5.3	Clay, white somewhat pisolitic slightly silty; brown streaks; whiter and less pisolitic below 12.2; C2
4	20.5	5.4	Clay, brown silty semi-plastic; yellowish-gray streaks; rock layers 15.1-15.8; sandy and more micaceous 15.8-18.7; few pebbles 18.7-20.5; C3
5	22.9	2.4	Clay, dark-gray highly micaceous and silty; C4

Remarks: This hole is about 5.5 ft. above top of 8-ft. outcrop about 25 ft. away; 8-inch auger used to rock layer at 15.1 and 4-inch auger below this.

L. V. FOWLER PROPERTY

TEST HOLE D34

Location T.5 S., R.2 E., Sec. 30, NW. 1/4 of SE. 1/4 (Benton County), 413 ft. east of hole D31 Drilled: Nov. 1, 1938
Elevation: 2 ft. above D31 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	4.0	4.0	Soil and subsoil, red clay and sand
			Fearn Springs
2	4.8	0.8	Clay, dark-gray silty plastic; yellow streaks; C1
3	7.9	3.1	Clay, light-gray silty plastic; C2
4	11.3	3.4	Clay, light-gray; sandy streaks; yellow streaks; C3
5	13.7	2.4	Clay, gray silty powdery; yellow streaks; C4
6	15.4	1.7	Clay, silty micaceous powdery; yellow streaks; C5
			Midway
7	30.1	14.7	Clay, white plastic; yellow streaks; slightly contaminated; C6
8	36.8	6.7	Clay, light-gray very micaceous and silty; C7
9	38.0	1.2	Clay, dark-gray very micaceous and silty; probably Porters Creek clay

GEORGE JOHNSON PROPERTY

TEST HOLE D39

Location: T.5 S., R.2 E., Sec. 30, NE. 1/4 of SW. 1/4 (Benton County), about 1075 ft. west of D31 Drilled: Nov. 27, 1938
Elevation: About 6 ft. above D31 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	7.1	7.1	Soil and subsoil, red clay
			Fearn Springs
2	8.2	1.1	Clay, dark-brown plastic; yellow streaks; C1
3	10.1	1.9	Clay, light-gray semi-plastic; very little silt: C2
4	11.9	1.8	Clay, dark-gray lignitic; C3
5	16.2	4.3	Clay, light-gray silty semi-plastic; yellow streaks; C4
6	19.4	3.2	Clay, dark-gray silty; yellow streaks; C5
7	21.2	1.8	Clay, dark-gray lignitic; C6
			Midway
8	36.9	15.7	Clay, white silty plastic; yellow streaks; C7
9	39.6	2.7	Clay, gray; probably Porters Creek clay

Remarks: Hole is 22 ft. above top of clay exposure in gullies on open spur.

L. V. Fowler Property

Test Hole D43

Location: T.5 S., R.2 E., Sec. 30, near east edge of SW. 1/4 of SE. 1/4 (Benton County), about 375 ft. S. 35° E. of hole D33 Drilled: Dec. 5, 1938
Elevation: about 6 ft. above D33 Water level: 12.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	4.4	4.4	Soil and subsoil, red sand
			Fearn Springs
2	12.6	8.2	Clay, gray silty slightly micaceous plastic; C1
3	13.5	0.9	Sand, gray; caved at 13.5

John Williamson Property

Test Hole D64

Location: T.8 S., R.4 E., Sec. 12, near west edge of NE. 1/4, on north side of dirt road and about half a mile east of Ellistown-Sherman road
Drilled: March 1-7, 1939
Elevation: 1 ft below road Water level: See remarks

No.	Depth	Thick.	Description of strata and designations of samples
1	1.2	1.2	Soil and subsoil, gray clay
			Ripley transitional clay
2	12.8	11.6	Clay, dark-gray calcareous; lime pebbles; C1
3	14.8	2.0	Clay, gray calcareous
4	19.9	5.1	Clay, dark-gray calcareous; lime pebbles; C2
5	25.3	5.4	Clay, dark-gray calcareous micaceous silty; contaminated
6	28.3	3.0	Clay, bluish-gray calcareous silty micaceous; lime pebbles; contaminated; C3
7	28.9	0.6	Clay, gray calcareous
8	38.9	10.0	Clay, gray calcareous silty micaceous; few lime pebbles; C4

Remarks: This log is a composite of 5 overlapping holes on the hillside. Material is much more uniform than is suggested by the descriptions. Selma chalk is exposed a few feet lower at the base of the hill.

JOHN WILLIAMSON PROPERTY

TEST HOLE D65

Location: T.8 S., R.4 E., Sec 12, NE. 1/4, about 685 ft. N. 55° E. of hole D64
Drilled: March 2-6, 1939
Elevation: About 15 ft. below D64 Water level: 23.2 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	1.0	1.0	Soil and subsoil
			Ripley transitional clay
2	13.8	12.8	Clay, dark-gray calcareous; C1
3	23.2	9.4	Clay, dark-gray calcareous, silty plastic; C2

JOHN WILLIAMSON PROPERTY

TEST HOLE D66

Location: T.8 S., R.4 E., Sec. 12, NE. 1/4, about 1250 ft. S. 85° E. of hole D64
Drilled: March 2, 1939
Elevation: About 15 ft. below D64 Water level: 8.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	2.0	2.0	Soil and subsoil, yellow sand and clay
			Ripley transitional clay
2	4.2	2.2	Clay, dark-gray and yellow micaceous, sandy, calcareous; C1
3	10.4	6.2	Clay, light-gray sandy, micaceous fossiliferous; C2
4	12.8	2.4	Clay, dark-gray micaceous slightly silty, calcareous; C3
5	16.0	3.2	Clay, dark-gray silty, micaceous, calcareous plastic; C4

H. E. DAVIS PROPERTY

TEST HOLE D67

Location: T.8 S., R.4 E., Sec. 12, SE. 1/4, about 1475 ft. S. 50° E. of hole D64
Drilled: March 3, 1939
Elevation: About 2 ft. above D64 Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	1.3	1.3	Soil and subsoil
			Ripley transitional clay
2	19.7	18.4	Clay, gray calcareous very silty and micaceous; C1
3	21.6	1.9	Clay, dark-gray calcareous, silty, micaceous plastic; C2

Remarks: D67 and D73 form a continuous section.

JOHN WILLIAMSON PROPERTY

TEST HOLE D71

Location: T.8 S., R.4 E., Sec. 12, NE. 1/4, about 945 ft. N. 65° E. of hole D64
Drilled: March 6-7, 1939
Elevation: About 37 ft. below D64 and 16 ft. above floodplain
Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	2.0	2.0	Soil and subsoil
			Ripley transitional clay
2	13.0	11.0	Clay, dark-gray calcareous; C1
3	14.8	1.8	Clay, dark-gray calcareous, micaceous; C2

JOHN WILLIAMSON PROPERTY

TEST HOLE D72

Location: T.8 S., R.4 E., Sec. 12, near north edge of SE. 1/4, about 1080 ft. S. 80° E. of hole D64
Drilled: March 6-7, 1939
Elevation: About 30 ft. below D64 and 15 ft. below D66 Water level: 12.2 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Ripley transitional clay
1	2.0	2.0	Clay, gray calcareous
2	10.7	8.7	Clay, light-gray calcarequs, silty, micaceous; C1
3	12.2	1.5	Clay, light-gray calcareous, micaceous, and silty

H. E. DAVIS PROPERTY

TEST HOLE D73

Location: T.8 S., R.4 E., Sec. 12, about 1350 ft. S. 40° E. of hole D64
Drilled: March 7, 1939
Elevation: About 20 ft. below D64 and 21.6 ft. below D67 Water level: 8.0 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	2.0	2.0	Soil and subsoil, yellow micaceous plastic clay
			Ripley transitional clay
2	14.3	12.3	Clay, yellow and gray calcareous, silty, micaceous plastic; no samples taken below water level; C1
3	16.8	2.5	Clay, dark-gray highly micaceous plastic

Remarks: D67 and D73 form a continuous section.

H. S. Gafford Property
Test Hole D87

Location: T.8 S., R.1 E., Sec. 9, NE. 1/4 of NW. 1/4, 915 ft. N. 32° W. of SE. corner (iron stake in center of road) of NE. 1/4 of NW. 1/4
Drilled: April 7-20, 1939
Elevation: About 20 ft. below iron corner stake Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	2.4	2.4	Soil and subsoil
			Midway
2	5.0	2.6	Clay, gray silty plastic; brown streaks; C1
3	7.9	2.9	Clay, cream-colored plastic; some silt at 7.3; C2
4	8.4	0.5	Clay, red; free from silt; yellow streaks; C3
5	11.5	3.1	Clay, gray; yellow and red streaks; thin rock at 11.0 C4
6	13.6	2.1	Clay, gray; brown and yellow streaks; rock pebbles; C5
7	16.3	2.7	Clay, yellow; white streaks; rock pebbles
8	19.2	2.9	Clay, white silty plastic; yellow streaks
9	20.8	1.6	Clay, gray silty semi-plastic; yellow streaks
10	21.6	0.8	Clay, dark-gray; yellow streaks
11	22.6	1.0	Clay, gray and purple; some yellow streaks
12	22.9	0.3	Clay, gray and yellow; lignitic streaks
13	24.1	1.2	Clay, lignitic; some yellow streaks
14	24.8	0.7	Clay, lignitic micaceous; gray streaks
15	25.7	0.9	Clay, gray; yellow and lignitic streaks
16	26.4	0.7	Clay, dark-gray highly micaceous; yellow streaks; probably Porters Creek clay

National Forest
Test Hole D91

Location: T.8 S., R.1 E., Sec. 4, SE. 1/4 of SW. 1/4, about 860 ft. N. 80° W. of SE. corner of SW. 1/4 of Sec. 4 Drilled: April 17-26, 1939
Elevation: About 10 ft. above SE. corner of SW. 1/4 Water level: 4.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	4.8	4.8	Soil and subsoil, red clay
			Midway
2	5.3	0.5	Clay, gray silty micaceous; yellow streaks
3	14.7	9.4	Clay, white; C1
4	19.5	4.8	Clay, yellow silty micaceous; gray streaks
5	23.4	3.9	Clay, yellow silty micaceous

O. D. GRAY PROPERTY
TEST HOLE D98

Location: T.8 S., R.1 E., Sec. 4, NW. 1/4 of SW. 1/4, 675 ft. S. 10° E. of rock marker 1680 ft. west of center of Sec. 4 Drilled: May 15, 1939
Elevation: About 3 ft. below rock marker Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	1.8	1.8	Soil and subsoil, red clay
			Fearn Springs
2	9.2	7.4	Clay, gray silty plastic; red streaks; rock pebbles throughout; C1
3	9.9	0.7	Sand, white micaceous; few yellow streaks; C2
4	10.4	0.5	Sand, gray; some gray clay and lignitic streaks; C3
5	11.4	1.0	Clay, gray silty micaceous plastic; yellow streaks; C4
6	12.1	0.7	Clay, lignitic; gray streaks; C5
7	12.8	0.7	Clay, gray plastic; yellow streaks; C6
8	14.4	1.6	Clay, gray; lignitic streaks; C7
9	15.4	1.0	Clay, gray silty semi-plastic; white streaks; C8
			Midway
10	16.1	0.7	Clay, white; gray streaks; C9
11	32.8	16.7	Clay, white plastic; yellow streaks from 23.0; C10
12	33.6	0.8	Clay, yellow semi-plastic; C11
13	38.3	4.7	Clay, gray plastic; yellow streaks; C12
14	39.7	1.4	Lignite (?); gray clay streaks
15	40.6	0.9	Clay, gray; lignitic (?) streaks
16	41.9	1.3	Lignite (?); gray clay streaks
17	43.3	1.4	Clay, probably Porters Creek

C. H. SIMMONS PROPERTY
TEST HOLE D101

Location: T.8 S., R.1 E., Sec. 10, SE. 1/4 of SW. 1/4, 880 ft. N. 15° W. of SE. corner of SW. 1/4 of Sec. 10 Drilled: Dec. 12-13, 1938
Elevation: 11 ft. below SE. corner of SW. 1/4 Water level: 16.2 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	2.5	2.5	Soil and subsoil, red
			Midway
2	5.2	2.7	Clay, gray slightly silty semi-plastic; yellow and lignitic streaks; C1
3	7.3	2.1	Clay, ocherous; slightly silty from 5.2 to 6.6; white streaks from 6.6 to 7.3; C2
4	11.4	4.1	Clay, white slightly silty plastic; few yellow streaks; C3
5	17.0	5.6	Clay, ocherous; slightly silty from 11.4 to 14.0; gradually whitens from 14.1 to 16.2; C4
6	30.0	13.0	Clay, yellow
7	31.2	1.2	Clay, dark micaceous silty; probably Porters Creek clay

H. S. Gafford Property

Test Hole D113

Location: T.8 S., R.1 E., Sec. 9, NE. 1/4 of NW. 1/4, 675 ft. N. 55° W. of SE. corner (iron stake in road) of SE. corner of NE. 1/4 of NW. 1/4 of Sec. 9
Drilled: Dec. 21, 1938
Elevation: Same as iron corner stake
Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	4.1	4.1	Soil and subsoil, red clay
			Fearn Springs?
2	11.4	7.3	Clay, gray; yellow streaks; C1
3	13.5	2.1	Clay, white micaceous silty plastic; C2
4	14.5	1.0	Clay, gray silty; lignitic streaks; C3
5	15.9	1.4	Clay, gray; lignitic streaks; C4
6	18.1	2.2	Clay, white plastic; yellow and lignitic streaks; C5

Remarks: This hole is just above an outcrop of fairly good-looking white clay. Hole abandoned on a rock while still in white clay.

O. D. Gray Property

Test Hole D128

Location: T.8 S., R.1 E., Sec. 4, SW. 1/4 of NW. 1/4, 495 ft. N. 15° W. of rock marker 1680 ft. west of center of Sec. 4
Drilled: Jan. 26, 1939
Elevation: 18 ft. below rock marker
Water level: 13.9 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	4.8	4.8	Soil and subsoil, red clay
			Midway
2	6.3	1.5	Clay, white semi-plastic; little silt; C1
3	7.0	0.7	Clay, lignitic; C2
4	8.0	1.0	Clay, light-gray; yellow streaks; C3
5	18.0	10.0	Clay, white silty semi-plastic; no samples below 13.9 on account of contamination; C4
6	20.0	2.0	Clay, ocherous silty micaceous
7	22.6	2.6	Clay, white silty micaceous semi-plastic
8	23.5	0.9	Clay, yellow micaceous silty semi-plastic; hole abandoned because of caving

Remarks: Samples C1-3 discarded.

O. D. Gray Property

Test Hole D137

Location: T.8 S., R.1 E., Sec. 4, NE. 1/4 of NW. 1/4 of SW. 1/4, 290 ft. S. 16° E. of rock marker 1680 ft. west of center of Sec. 4. Drilled: Jan. 27-31, 1939
Elevation: About 20 ft. below rock marker Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	1.3	1.3	Soil and subsoil, clay and sand
			Midway
2	7.8	6.5	Clay, white; free from silt and mica; thin yellow streaks; C1
3	9.9	2.1	Clay, white pisolitic; yellow streaks; C2
4	15.8	5.9	Clay, light-brown; white and dark streaks; hole closed on unbreakable rock; C3

Remarks: This clay is exposed at an old sawmill site nearby, and was sampled more thoroughly by D186, about 75 ft. away.

A. F. Rhea Property

Test Hole D142

Location: T.7 S., R.1 E., Sec. 8, SE. 1/4 of NW. 1/4, 63 ft. N. 15° W. of iron stake 950 ft. west of center of Sec. 8 Drilled: Feb. 16, 1939
Elevation: 7.5 ft. below iron stake Water level: 14.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	2.8	2.8	Soil and subsoil, gray sand
			Wilcox
2	11.5	8.7	Sand, white; yellow streaks; C1
3	18.9	7.4	Sand, reddish-yellow; C2
4	21.8	2.9	Sand, light-yellow; hole closed because of caving; C3

A. F. Rhea Property

Test Hole D143

Location: T.7 S., R.1 E., Sec. 8, NE. 1/4 of SW. 1/4, 200 ft. south of iron stake 950 ft. west of center of Sec. 8 Drilled: Feb. 8-13, 1939
Elevation: 6 ft. above iron stake Water level: 27.4 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	2.3	2.3	Soil and subsoil, yellow and white sand
			Wilcox
2	8.2	5.9	Sand, white fine-grained; C1
3	12.1	3.9	Sand, yellow; red streaks
4	17.2	5.1	Sand, light-gray fine-grained; C2
5	22.8	5.6	Sand, white micaceous; C3
6	26.7	3.9	Sand, yellow
7	31.9	5.2	Sand, gray; hole closed because of caving

F. L. FORD PROPERTY

TEST HOLE D146

Location: T.7 S., R.1 E., Sec. 8, NE. 1/4 of SW. 1/4, 205 ft. south of iron stake 950 ft. west of center of Sec. 8 Drilled: Feb. 13-17, 1939

Elevation: 21 ft. above iron stake Water level: 16.1 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	11.0	11.0	Soil and subsoil
			Wilcox
2	16.1	5.1	Sand, light-yellow; C1
3	19.4	3.3	Sand, white; C2
4	25.4	6.0	Sand, dark-yellow
5	26.8	1.4	Sand, white; C3
6	31.4	4.6	Sand, dark-yellow
7	36.5	5.1	Sand, white; hole closed because of caving; C4

A. F. RHEA PROPERTY

TEST HOLE D154

Location: T.7 S., R.1 E., Sec. 8, SE. 1/4 of NW. 1/4, 81 ft. north of iron stake 950 ft. west of center of Sec. 8. Drilled Feb. 18, 1939

Elevation: 4 ft. below iron stake Water level: 15.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	1.2	1.2	Soil and subsoil, brown sand
			Wilcox
2	2.6	1.4	Sand, white; yellow streaks 1.8 to 1.9; C1
3	4.9	2.3	Sand, yellow; few yellow streaks; C1
4	6.1	1.2	Sand, yellow; white streaks; C1
5	8.0	1.9	Sand, white; red streaks; C1
6	9.0	1.0	Sand, yellow; white streaks; C1
7	14.0	5.0	Sand, white micaceous; yellow streaks; C1
8	14.9	0.9	Sand, yellow; red and white streaks; C1
9	15.6	0.7	Sand, white; yellow streaks; C1
10	16.8	1.2	Sand, red; white streaks
11	31.6	14.8	Sand, red

C. L. HEARN PROPERTY

TEST HOLE D156

Location: T.8 S., R.1 E., Sec. 9, NE. 1/4 of NW. 1/4, 975 ft. N. 65° W. of SE. corner (iron stake in road) of NE. 1/4 of NW. 1/4 of Sec. 9

Drilled: Feb. 21, 1939

Elevation: 20 ft. below iron stake Water level: 12.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	5.8	5.8	Soil and subsoil, gray clay
			Midway
2	12.8	7.0	Clay, white plastic; yellow streaks; C1
3	21.2	8.4	Clay, yellow plastic; white streaks
4	28.3	7.1	Clay, white plastic
5	30.5	2.2	Clay, dark-gray micaceous; probably Porters Creek clay

HUB THOMAS PROPERTY

TEST HOLE D160

Location: T.8 S., R.1 E., Sec. 23, NW. 1/4 of NW. 1/4 (Pontotoc County), about 500 ft. southeast of road corner on county line, back of house

Drilled: Feb., 1939

No.	Depth	Thick.	Description of strata and designations of samples
			Wilcox
1		6.0	Sample of sand taken from dug well between depths of 17 and 23 ft. This 6-ft. interval is said to have only a few thin red streaks, which are included in sample. Bottom of well did not reach bottom of white sand, as water was encountered in the sand.

MORRIS ESTATE

TEST HOLE D161

Location: T.7 S., R.3 E., Sec. 18, NW. 1/4 of NW. 1/4, 2500 ft. west of Tallahatchie bridge, and 69 ft. south of local road Drilled: April 8, 1939

Elevation: 5 ft. above floor of bridge Water level: 2.9 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	1.2	1.2	Soil and subsoil
2	9.6	8.4	Clay, gray silty; red streaks; C1
3	13.8	4.2	Clay, dark-gray silty plastic; C2
4	16.0	2.2	Clay, dark-gray and blue sandy micaceous plastic; C3
5	17.6	1.6	Sand, yellow; brown streaks; C4

NATIONAL FOREST

TEST HOLE D164

Location: T.8 S., R.1 E., Sec. 4, near center of SW. 1/4

Drilled: May 11-17, 1939

Elevation: About 10 ft. above SE. corner of SW. 1/4 of Sec. 4

Water level: 34.5 ft. (slow seep)

No.	Depth	Thick.	Description of strata and designations of samples
1	3.6	3.6	Soil and subsoil
			Fearn Springs
2	7.6	4.0	Clay, gray sandy semi-plastic; brown streaks; rock pebbles; C1
3	12.0	4.4	Clay, gray slightly micaceous plastic; brown and yellow streaks; C2
4	14.1	2.1	Clay, gray sandy; brown streaks; C3
5	17.4	3.3	Lignite; white streaks; C4
			Midway
6	22.5	5.1	Clay, white plastic; brown streaks; C5
7	26.7	4.2	Clay, brown slightly silty plastic; white streaks; C6
8	27.9	1.2	Clay, dark-brown silty; white streaks
9	31.4	3.5	Clay, white silty; brown streaks
10	34.5	3.1	Clay, gray silty slightly micaceous; yellow streaks
11	35.9	1.4	Sand, gray; yellow, green, and lignitic streaks
12	38.1	2.2	Clay, dark-gray highly micaceous; probably Porters Creek clay

NATIONAL FOREST

TEST HOLE D171

Location: T.8 S., R.1 E., Sec. 4, NE. 1/4 of SW. 1/4, about 350 ft. easterly of hole D164

Drilled: May 18-23, 1939

Elevation: Same as D164

Water level: 8.4 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	3.8	3.8	Soil and subsoil
			Fearn Springs
2	6.8	3.0	Clay, light-brown silty micaceous; rock pebbles; yellow streaks; C1
3	12.8	6.0	Clay, light-gray silty micaceous; yellow streaks; C2
4	17.0	4.2	Clay; same as No. 3, but some black streaks; C3
			Midway
5	21.8	4.8	Clay, white and yellow slightly silty; black streaks; C4
6	24.4	2.6	Clay, light-yellow silty micaceous; black streaks; C5
7	26.0	1.6	Clay, white sandy micaceous; black streaks; C6
8	27.8	1.8	Clay, dark-gray silty micaceous; yellow streaks; C7

C. J. MYERS PROPERTY

TEST HOLE D182

Location: T.6 S., R.1 E., Sec. 24, SW. 1/4, on steep west wall of Locke Creek
Collected: Feb., 1939

No.	Depth	Thick.	Description of strata and designations of samples
1	10.0	10.0	Porters Creek clay; C1
2	20.0	10.0	Porters Creek clay; C2
3	30.0	10.0	Porters Creek clay; C3
4	40.0	10.0	Porters Creek clay; C4
5	50.0	10.0	Porters Creek clay; C5

Remarks: Depths read up from creek bed at foot of a 50-foot bluff of Porters Creek clay. Material from here is reported to have been shipped to Memphis for experimental purposes.

MISSISSIPPI HIGHWAY DEPARTMENT

TEST HOLE D183

Location: T.6 S., R.3 E., Sec. 16, near center of Sec., east side of Highway 15, 2 1/2 miles south of Cotton Plant Collected: April 11, 1939

No.	Depth	Thick.	Description of strata and designations of samples
1	18.0	18.0	Prairie Bluff marl; P1

Remarks: Sample collected from face of fresh cut for the new highway.

TEST HOLE D185

Location: T.7 S., R.2 E., Sec. 10, near E. edge, about 1/4 mile north of Highway 30 on west side of Hell Creek, in big erosion gully
Collected: March 8-13, 1939

No.	Depth	Thick.	Description of strata and designations of samples
1	0.3	0.3	Soil and subsoil
2	33.2	32.9	Porters Creek clay C1: 0.3-11.7 ft.; C2: 11.7-22.7 ft.; C3: 22.7-33.2 ft.

Remarks: Samples collected from a series of trenches and pits, commencing at top of knoll, dug in side and bottom of south-draining gully. Ownership of property unknown as it is said to have changed hands many times recently.

O. D. Gray Property

Test Hole D186

Location: T.8 S., R.1 E., Sec. 4, NW. 1/4 of SW. 1/4, 225 ft. south of rock marker 1680 ft. west of center of Sec. 4 Drilled: March 4, 1939
Elevation: 11 ft. below rock marker Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	1.6	1.6	Soil and subsoil
			Fearn Springs
2	3.8	2.2	Clay, red; light streaks
3	7.2	3.4	Clay, gray; red streaks; rocks
4	7.6	0.4	Clay, white highly plastic
5	9.8	2.2	Sand, yellow
			Midway
6	10.9	1.1	Clay, gray silty micaceous plastic; C1
7	13.0	2.1	Clay, slightly lignitic silty; C1
8	17.5	4.5	Clay, gray plastic; C3
9	18.4	0.9	Clay; changing to creamy-gray
10	23.8	5.4	Clay, white; very little silt; C4
11	24.8	1.0	Clay, white slightly silty; few yellow streaks; C5
12	29.6	4.8	Clay, light-gray; stained yellow; C6
13	30.6	1.0	Clay, light-gray gritty; slightly yellow
14	34.6	4.0	Clay, light-gray gritty micaceous
15	36.9	2.3	Clay, Porters Creek

Remarks: Clay exposed nearby at an old sawmill site. Samples obtained from auger hole in bottom of pit 7.2 ft. deep. This hole is about 75 ft. from D137, and is 90 ft. north of an old sawdust pile.

NATIONAL FOREST

TEST HOLE D187

Location: T.7 S., R.1 E., Sec. 33, NW. 1/4 of SW. 1/4, at top of small hill about 1/4 mi. west of Salem church, and about 300 ft. south of east-west mid-line of Sec. 33 Collected: March 21, 1939

Elevation: Top of hill Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	1.9	1.9	Soil and subsoil
			Midway
2	4.4	2.5	Bauxitic clay or soft bauxite; gray with yellow spots
3	7.4	3.0	Bauxite, hard reddish-brown; gray streaks of soft bauxite
4	8.4	1.0	Bauxite, soft gray and yellow
5	9.0	0.6	Bauxite, hard ferruginous concretionary
6	9.5	0.5	Clay, soft ferruginous bauxitic; transitional from bauxite to underlying white clay; lower limit irregular and indistinct; C1
7	11.5	2.0	Clay, light chocolate-brown; free from silt; C2
8	12.2	0.7	Clay, white; free from silt; red on joints; C3
9	18.2	6.0	Clay white slightly silty coarsely pisolitic; C4
10	18.8	0.6	Clay, white; yellow streaks; C4
11	23.0	4.2	Clay, yellow slightly silty; white streaks; C5
12	27.8	4.8	Rock, about 0.7 ft.; white silty clay too badly contaminated to sample but similar to No. 11
13	29.8	2.0	Clay, white silty micaceous; C6
14	32.4	2.6	Clay, gray silty micaceous; yellow streaks
15	33.3	0.9	Clay, dark-gray highly micaceous; Porters Creek clay

Remarks: This was formerly the L. B. Busby property. Old bauxite pit was reopened and deepened to 18.2; from there to 23.0 samples taken from 8-inch auger hole; below that from 4-inch auger hole.

KINLOCH OWEN PROPERTY

TEST HOLE D197

Location: T.7 S., R.3 E., Sec. 19, W. 1/2, 925 ft. east of grade crossing near west edge of Sec. 19 Drilled: April 13, 1939

Elevation: About the same as the crossing Water level: 4.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Colluvial Clayton
1	2.8	2.8	Soil and subsoil
2	10.0	7.2	Clay, dark-gray micaceous plastic; red streaks; pebbles; C1
3	13.8	3.8	Clay, gray sandy micaceous; C2
			Prairie Bluff
4	14.0	0.2	Clay, dark-blue sandy micaceous calcareous

Will Speck Property

Test Hole D199

Location: T.7 S., R.2 E., Sec. 24, E. 1/2, 800 ft. N. 80° W. of grade crossing near east edge of Sec. 24 Drilled: April 13, 1939
Elevation: 3 ft. above the crossing Water level: 7.9 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	3.0	3.0	Soil and subsoil
2	7.9	4.9	Clay; yellow pebbles; gray streaks; C1
3	10.5	2.6	Clay, yellow; gray streaks; pebbles; C2
4	16.3	5.8	Clay and sand; pebbles; C3
5	20.8	4.5	Sand; C4

E. J. Stephens Property

Test Hole D201

Location: T.7 S., R.3 E., Sec. 19, NE. 1/4 of SW. 1/4, 1840 ft. S. 80° E. of grade crossing at west edge of Sec. 19 Drilled: April 14, 1939
Elevation: 15 ft. above grade crossing Water level: 2.4 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Colluvial Clayton
1	1.4	1.4	Soil and subsoil
2	8.0	6.6	Sand, gray; yellow streaks; rock pebbles; C1
3	12.8	4.8	Sand, yellow; C2
4	15.2	2.4	Clay, yellow sandy micaceous; C3
			Prairie Bluff
5	15.8	0.6	Clay, dark-gray calcareous micaceous; shell fragments

A. J. Barkley Property

Test Hole D204

Location: T.6 S., R.3 E., Sec. 16, SE. 1/4 of NW. 1/4, 2500 ft. north of Gulf, Mobile & Ohio bridge, 330.3, and 40 ft. west of the track
Drilled: April 15, 1939
Elevation: About 8 ft. above R. R. bridge 330.3 Water level: 8.4 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	0.6	0.6	Soil and subsoil
2	12.2	11.6	Clay, bluish-gray sandy; yellow streaks; few rock pebbles; C1

Remarks: From Lukesaspa Creek "bottom."

MISSISSIPPI HIGHWAY DEPARTMENT

TEST HOLE D207

Location: T.7 S., R.3 E., Sec. 29, NW. 1/4 of NW. 1/4, in cut on Highway 15 on south wall of King Creek Collected: May 16, 1939

No.	Depth	Thick.	Description of strata and designations of samples
1	16.2	16.2	Prairie Bluff marl; P1
2	21.2	5.0	Covered; no samples
3	33.9	12.7	Prairie Bluff marl; P2

Remarks: Samples taken from trenches in good exposures.

WILL FOSTER PROPERTY

TEST HOLE D220

Location: T.7 S., R.2 E., Sec. 13, NW. 1/4 of NW. 1/4, 505 ft. S. 60° E. of NW. corner of Sec. 13 Drilled: June 1-2, 1939
Elevation: 5 ft. above road corner Water level: 4.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	0.8	0.8	Soil
2	20.5	19.7	Clay, yellow sandy; gray streaks; C1
3	21.0	0.5	Sand, yellow
4	23.4	2.4	Clay, brown sandy; rock at 23.4

JIM DODDS PROPERTY

TEST HOLE D221

Location T.7 S., R.2 E., Sec. 12, SW. 1/4 of SW. 1/4, about 400 ft. east of SW. corner of Sec. 12, beside road Drilled: June 2, 1939
Elevation: About same as road corner Water level: 4.0 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	0.8	0.8	Soil and subsoil
2	15.9	15.1	Clay, gray and yellow; rock pebbles at 7.0; C1

Remarks: Hole closed on account of rock.

WILL ROGERS PROPERTY
TEST HOLE D222

Location: T.6 S., R.2 E., Sec. 26, near SW corner, 150 ft. south of U. S. Highway 78 Drilled: June 1, 1939
Elevation: 1.5 ft. above highway Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	0.8	0.8	Soil
2	2.2	1.4	Clay, yellow silty plastic; C1
3	3.7	1.5	Clay, light-gray silty plastic; C1
4	6.2	2.5	Clay, yellow; light-gray streaks; C1
5	10.4	4.2	Clay, light-gray; yellow streaks; C2
			Porters Creek
6	13.0	2.6	Clay, yellow silty micaceous; dark-gray streaks and pebbles; C3
7	14.4	1.4	Clay, dark-gray silty micaceous; probably Porters Creek clay; C3

A. H. COFFEE PROPERTY
TEST HOLE D225

Location: T.6 S., R.2 E., Sec. 18, near east edge of Sec. 18 (possibly west edge of Sec. 17), about 0.1 mi. north of junction of old and new U. S. Highway 78, and about 100 yds. east of railroad Drilled: June 2, 1939
Elevation: 12 ft. above railroad Water level: 13.1 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium or Colluvium
1	0.8	0.8	Soil and subsoil
2	13.1	12.3	Clay and sand, yellow; gray streaks; C1
3	18.1	5.0	Sand, gray; C2
			Porters Creek
4	19.1	1.0	Clay, dark-gray micaceous; probably Porters Creek clay

W. H. Ross Property

Test Hole D227

Location: T.6 S., R.2 E., Sec. 6, SW. 1/4 of NE. 1/4, about 1080 ft. east of Frisco track at a point 1325 ft. south of old Highway 78 grade crossing near Union-Benton County line, and on top of a small knoll

Drilled: June 2, 1939

Elevation: 12 ft. above railroad track — Water level: 30 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	1.4	1.4	Soil, yellow sand and clay
2	10.6	9.2	Clay, yellow sandy; thin streaks of gray clay at 9.7; C1
3	14.6	4.0	Clay, yellow; light-gray sand; C2
4	18.3	3.7	Sand, yellow; light-gray streaks; sandstone pebbles at 18.3; C3
5	29.4	11.1	Sand, light-gray and yellow micaceous; streaks of light-gray clay; C4
6	32.0	2.6	Sand, light-gray micaceous; yellow streaks; hole closed because of caving; C4

Remarks: Chiefly sand, probably an old terrace deposit, though possibly Wilcox material. Large quantities probably present for blending with nearby clays.

W. L. Newton Property

Test Hole D229

Location: T.6 S., R.3 E., Sec. 33, NE. 1/4, 435 ft. S. 15° W. of TVA pole 535

Drilled: June 3, 1939

Elevation: 15 ft. below TVA pole 535 — Water level: 9.4 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Alluvium
1	0.8	0.8	Soil and subsoil
2	14.4	13.6	Clay, yellowish-red; gray sand streaks from 9.4; C1
3	20.4	6.0	Sand, light-red; gray clay streaks at 19.1; C2
4	22.5	2.1	Clay, dark-gray sandy micaceous; probably alluvium derived from Prairie Bluff marl; C3

Remarks: Probably an old terrace deposit along Cane Creek.

STATE HIGHWAY DEPARTMENT

TEST HOLE D232

Location: T.5 S., R.2 E., Sec. 31, NW. 1/4 of SW. 1/4 (Benton County), east side of old U. S. Highway 78, 2965 ft. north of grade crossing

Drilled: June 6, 1939

Elevation: About 30 ft. above old Highway 78 grade crossing

Water level: 4.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	1.0	1.0	Soil and subsoil, gray clay
			Fearn Springs
2	5.2	4.2	Clay, gray silty plastic; brown streaks; C1
3	6.7	1.5	Clay, lignitic; C2
4	7.8	1.1	Clay, gray lignitic slightly silty; contaminated; C3
5	14.1	6.3	Clay, gray silty; yellow-brown streaks; C.4

Remarks: D261 is only half a mile away and available for blending. Hole is just above clay outcrops in road ditch.

L. V. FOWLER PROPERTY

TEST HOLE D257

Location: T.5 S., R.2 E., Sec. 30, NW. 1/4 of SE. 1/4 (Benton County), 4 ft. west of test hole D34

Drilled: June 3-19, 1939

Elevation: 1.8 ft. above D34

Water level: 4 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	4.0	4.0	Soil and subsoil, red clay and sand
			Fearn Springs
2	4.8	0.8	Clay, dark-gray silty plastic; thin yellow streaks; C1
3	7.9	3.1	Clay, light-gray silty plastic; C2
4	11.2	3.3	Clay, light-gray; yellow sandy streaks; C3
5	13.7	2.5	Silt, dark-gray; thin streaks of white clay; C4
6	15.8	2.1	Silt, light-gray micaceous; streaks of white and yellow clay; darker at 15.0, still darker at 15.4; C5
			Midway
7	16.2	0.4	Clay, gray silty plastic; small yellow streaks; C6
8	32.5	16.3	Clay, light-gray plastic; slightly contaminated by silt from above; becomes increasingly silty and micaceous with depth, notably about 28.4; C7
9	36.5	4.0	Clay, light-gray silty micaceous; C8
10	37.5	1.0	Clay, dark-gray; probably Porters Creek clay; C9

Remarks: A boxed and drained pit was dug to the top of the clay at 4 ft.; samples were taken below that with an 8-inch auger.

STATE HIGHWAY DEPARTMENT

TEST HOLE D260

Location: T.5 S., R.2 E., Sec. 31, SW. 1/4 of SW. 1/4 (Benton County), east edge of old U. S. Highway 78, 1355 ft..north of Benton-Union County line, and 775 ft. south of test hole D232 Drilled: June 14-15, 1939
Elevation: 25 ft. above old Highway 78 grade crossing Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	3.1	3.1	Soil and subsoil, gray clay
			Fearn Springs
2	9.9	6.8	Clay, gray silty; C1
3	14.1	4.2	Clay, gray and yellow; sand layers; C2
4	20.0	5.9	Clay, gray micaceous silty; brown streaks; C3
5	27.0	7.0	Clay, dark-blue silty micaceous; possibly Porters Creek clay, but more likely Fearn Springs clay; C4

Remarks: This hole is a short distance down the old highway from D232, and somewhat lower. These clays and those from D261, about 500 yds. away, could easily be blended.

W. H. ROSS PROPERTY

TEST HOLE D261

Location: T.6 S., R.2 E., Sec. 6, NE. 1/4 of NW. 1/4, 480 ft. N. 17° E. of old U. S. Highway 78 grade crossing Drilled: June 14, 1939
Elevation: 20 ft. above grade crossing Water level: 16.8 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	0.8	0.8	Soil and subsoil, red clay
			Fearn Springs
2	4.4	3.6	Clay, yellow silty; C1
3	8.8	4.4	Clay, red; gray sand streaks; pebbles at 8.2; C2
4	10.4	1.6	Clay, gray silty micaceous; yellow sand streaks; C3
5	20.4	10.0	Sand, gray; yellow and red streaks; hole closed on account of caving; C4

Remarks: See remarks on D260.

National Forest
Test Hole D270

Location: T.5 S., R.2 E., Sec. 29, SE. 1/4, (Benton County), about 800 ft. southeast of road fork, on west side of road opposite an old house site
Collected; June 22, 1939

Elevation: About 25 ft. below road fork. Water level: 16.2 ft.

No.	Depth	Thick.	Description of strata and designations of samples
			Fearn Springs
1	2.0	2.0	Soil and subsoil, gray laminated clay; lower limit irregular
2	3.0	1.0	Siderite, irregular concretionary; upper and lower limits irregular
			Midway
3	12.0	9.0	Clay, light-gray silty, bauxitic; lower 1 foot gradually becomes yellow; P1
4	14.0	2.0	Clay, ocherous slightly silty; C1
5	16.2	2.2	Clay, light-gray silty, bauxitic
6	17.6	1.4	Sand, yellow; gray streaks; hole closed because of caving

Remarks: Test pit is just up the slope from a poor surface exposure of bauxitic clay.

D. M. Foster Property
Test Hole D271

Location: T.6 S., R.2 E., Sec. 6, NW. 1/4, 30 ft. north of mid-section fence and 350 ft. west of U. S. Highway 78 Drilled: June 21, 1939

Elevation: 16 ft. above U. S. Highway 78 Water level: 14.6 ft.

No.	Depth	Thick.	Description of strata and designations of samples
1	2.2	2.2	Soil and subsoil, red sand clay
			Fearn Springs
2	4.8	2.6	Clay, yellow and gray; some light-gray sand; C1
3	8.0	3.2	Sand, yellow; light-gray slightly micaceous clay; C2
4	8.8	0.8	Sand, light-gray micaceous; C3
5	12.8	4.0	Sand, yellow and gray; light-gray and yellow clay; C4
6	15.2	2.4	Clay, dark-gray sandy, micaceous; light-gray and yellow streaks; C5
7	17.6	2.4	Sand, light-gray and yellow; light-gray streaks of clay; C6
8	21.2	3.6	Clay, light-gray micaceous plastic; yellow streaks of sand; C7
9	23.5	2.3	Sand and clay, light-gray; C8
10	25.0	1.5	Sand, yellow and light-gray micaceous; contaminated; C9

Remarks: Sand, available for blending with clays D260 and D261 near the Benton County line.

ARTHUR ROGERS PROPERTY

TEST HOLE D301

Location: T.7 S., R.3 E., Sec. 7, NW. 1/4, 315 yds. south of Highway 30, near top of slope in a young fruit orchard
Drilled: July 8-14, 1939
Water level: No water

No.	Depth	Thick.	Description of strata and designations of samples
1	0.4	0.4	Soil
			Weathered Clayton
2	20.3	19.9	Clay, red sandy; C1
3	24.8	4.5	Clay, red sandy; dark-gray streaks; C2

OLD BUSBY BRICK PLANT PROPERTY

TEST HOLE D303

Location: T.7 S., R.3 E., Sec. 8, SW. 1/4, 0.1 mi. east of Highway 15 and 0.6 mi. south of New Albany courthouse
Collected: July 21, 1939
Elevation: Beside fence at top of old pit

No.	Depth	Thick.	Description of strata and designations of samples
			Weathered Clayton
1	14.0	14.0	Clay, red sandy

Remarks: Trench sample from pit of old brick plant.

ACKNOWLEDGMENTS

The Works Progress Administration supplied the labor and financial aid without which the survey of Union County could not have been undertaken. The administrative staff of that organization showed much interest in the work and did much to help in many ways, so that particular mention is due to Miss Ethel Payne, State Director; Mrs. Amalie S. Fair, Assistant Director; Mrs. Mary Paine Harvey, Field Supervisor; and Mrs. Mary D. Stevens, Area Supervisor; all of the Division of Professional and Service Projects of the Mississippi Works Progress Administration. Mr. F. E. Vestal, Project Supervisor, visited the field several times and made many helpful suggestions.

Mr. Watson H. Monroe of the United States Geological Survey spent a day with the writer in the central and eastern parts of the county and made many valuable suggestions based on his previous work in the county. Mr. Glen F. Brown and V. M. Foster, also of the United States Geological Survey, each spent a day with the writer in the western part of the county and helped check some details.

The New Albany Chamber of Commerce supplied office and storage space, and most of the materials used in the field work. Mr. N. H. Crenshaw, its secretary, made many of the advance arrangements, while Mr. Arthur Rogers and Mr. James G. Houston were especially helpful during the progress of the survey in too many ways to mention.

Mr. Andrew Brown prepared the base map, was a valuable geological assistant, and, in so many other ways, contributed to the efficiency of the project that it is quite impossible to give him due credit. Mr. H. E. Whitten, who served as Supervisor on the project, assumed entire charge of the labor in the field, and to his interest and conscientious work the survey is greatly indebted.

The Mississippi Geological Survey supplied the technical supervision, contributed some of the material, and is publishing this report. The entire staff of the Survey has contributed in many ways to the success of the project, but special thanks are due Mr. F. F. Mellen, who has supervised similar work in other counties of the state, and who gave freely of his limited time to help get the project underway in Union County, and on many later occasions made helpful suggestions. Dr. W. C. Morse, Director of the Mississippi Geological Survey, in his capacity of Technical Director, has so instilled the spirit of accuracy and thoroughness into the entire personnel that any permanent value this survey may have will reflect his influence.

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UNION COUNTY MINERAL RESOURCES TESTS

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

INTRODUCTION

The clays of Union County are from the same geologic beds as those from adjoining Tippah County which were reported in Bulletin 42 of the Mississippi Geological Survey. On comparing the clays from the two counties some interesting observations were noted which would not be especially obvious when studying the clays cf the two counties separately. For this reason and for the purpose of presenting a broader conception of the general area of Benton, Tippah, and Union Counties frequent reference will be made in this report to the clays previously reported in Bulletin 42.

In the Tippah county report the important clays were classified as hard kaolin, soft kaolin, upper pottery-brick and tile clays (above the kaolin horizon), lower pottery-brick and tile clays (below the kaolin horizon), and clays of the Porters Creek formation. This same classification, however, is not entirely applicable to the clays of Union County, due to the differences in quantity, quality and character between the clays of the two counties that have relative stratigraphic positions.

The following summation is briefly the contrast between the several types of clay from the two counties:

Hard kaolins.

In Union County the hard kaolins are much thicker than in Tippah County. They are generally higher in alumina, and some contain considerable amounts of gibbsite (bauxite) which was not present in any appreciable amount in the Tippah County kaolins.

Soft kaolins.

In Tippah County a number of deposits of high grade fine-grained soft kaolins were reported. This clay is conspicuously absent in Union County. This type of clay in Union County is highly contaminated with silt and siderite.

Upper pottery-brick and tile clays.

In Tippah County this clay was reported as being of poorer quality than the lower pottery clay, generally sandy and in fairly thin strata. In Union County this clay is much thicker, a number of samples representing over 20 feet of clay. It is somewhat silty and carbonaceous, but it is of good quality for heavy clay products.

Lower pottery-brick and tile clays.

A number of samples of good quality were reported from Tippah County. This clay seems to be absent in Union County, or it was too deep to be penetrated with hand augers.

Porters Creek clay.

The middle phase or light-weight variety of this clay in Union County is somewhat contaminated with silt and iron oxide, and is not as light in weight as the Tippah County material.

These variations between comparable strata of the two counties, whether due to geologic processes, or position, or sampling, have an important bearing on the economic aspect in the following ways:

1. The higher alumina content and greater thickness of the high grade kaolin-gibbsite clays make them more promising for development by the metallurgical and chemical industries for the production of aluminum metal and aluminum salts.

2. The absence of high grade fine-grained kaolins in Union County diminishes the number of opportunities for development in this area.

3. Good quality pottery-brick and tile clay in great thickness near the surface in Union County offers a better opportunity for a modern heavy clay product plant than similar clay in thinner strata and equal quality clay in deeper strata of Tippah County.

4. A light-weight aggregate plant utilizing the Porters Creek clay from Tippah County would make a better product than it would by using a similar material from Union County.

These comparisons and observations are based on results of tests of a great number of clays from the two counties, but they are not necessarily conclusive as it is not assumed that all deposits in both counties have been tested. It is not to be implied that the difference in character of material from place to place is a matter of a county line boundary, but it is thought to be the general trend in the region.

CLASSIFICATION OF CLAYS AND MINERALS

In this report the clays are classified as follows:

1. Surface clays.

These clays mantle the more plastic clays of the Fearn Springs formation (D22 C1), or are flood plain alluvium (D161 1.2-17.6), or represent weathered Clayton soil (D197 C1-2). They are grouped together, because they are very sandy and silty, are red burning, and have other comparable characteristics.

2. Brick and tile clays.

This group of clays is from the Fearn Springs formation. They are subdivided in this report as the silty variety and the carbonaceous variety. The silty variety (D22 C2-3) seems to be above the carbonaceous clay and grades upward into the surface clay. The carbonaceous variety (D39 7.1-21.2) is so termed because of its characteristic purplish lignitic appearance. Both varieties have comparable physical and pyro-chemical properties. The carbonaceous phase appears to be higher in alumina and grades downward into kaolinitic clays in some localities and into sand in other localities.

3. High alumina clays.

The high alumina clays of Tippah County were classified as hard kaolin and soft kaolin. Their stratigraphic position according to Conant is the uppermost part of the Midway and according to Mellen is the major part of the Betheden formation. In Union County these clays have the same stratigraphic position but in the strictest sense are not necessarily true kaolins inasmuch as a number of samples were found to contain considerable amounts of gibbsite and are consequently higher in alumina than typical kaolins. Since it was not possible to check the mineralogical content of each sample and since it is shown in the test part of this report that the kaolinite and gibbsite concentration is gradational, the entire group of clays will hereafter be referred to as high alumina clays. In this report they have been subdivided into two phases designated as the low iron group and the limonitic group. In general the concentration of iron is toward the bottom of the deposit (D186 C5-6, D 137 C3), but in some test holes contamination from above has stained the upper clay (D20 6.7-18, D101 2.5-17) to such an extent that the samples are classified in the limonitic series. Chemical analyses of seven typical clays of the high alumina-low iron series show that the average alumina content is 44.63 percent and that the iron content (Fe_2O_3) is 1.15 percent. Chemical analyses of three samples from the high alumina-limonitic series show that the average alumina content is 37.29 percent and the average iron content (Fe_2O_3) is 5.4 percent.

4. Miscellaneous clays.

The clays in this group are from the Midway-Wilcox contact. Some of the samples are composed of material from both the Fearn Springs and Betheden formations (D22 C8), and, consequently, could not be classified strictly according to the previous groups. Other samples represent a thick series of Fearn Springs clays containing both the carbonaceous and silty variety and some kaolin from the upper part of the Betheden (D1 11-31.7). The third type of clay is represented in this group by the fine-grained silty kaolins containing large amounts of siderite (D22 C9-10, D39 21.2-36.9).

5. Porters Creek clays.

This group is composed of clays from three test holes. Material from test hole D182 is of the light-weight variety but highly contaminated with silt and iron oxide. The material from test hole D185 is typical of the light-weight material or middle phase of the Porters Creek clay. Sample D222 C1-2-3 appears to be a transitional clay composed essentially of the light-weight variety of Porters Creek clay and some plastic pottery clay.

6. Calcareous clays.

All of the clays in this group are designated by Conant as being from the Ripley formation and are called Ripley transitional clays. The samples appear to be very similar and represent different parts of the deposit in the locality from which they were sampled.

7. Marl.

Three samples of Prairie Bluff marl from two test holes compose this group.

8. Sand.

Eight samples of white to light colored sand from the Wilcox series and two samples of sandy clay highly contaminated with limonite comprise the variety of material submitted for testing. Material from test hole D303 was formerly used in the manufacture of brick but is classified in this report as sand.

SURFACE CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thickness in percent	Water of plasticity in percent	Drying shrinkage		Texture	Color
				Volume in percent	Linear in percent		
D22	C1	4.0	19.75	12.52	4.39	Silty	Yellowish gray
D161	1.2–17.6	16.4	22.49	26.67	9.84	Silty	Yellowish gray
D197	C1–2	11.0	28.68	31.46	11.85	Silty	Yellowish gray
D199	3.0–20.8	17.8	19.17	18.49	6.59	Silty	Yellowish gray
D201	1.4–15.2	13.8	17.04	11.52	4.03	Sandy	Yellowish gray
D204	C1	11.6	26.52	35.92	13.82	Silty	Yellowish gray
D220	C1	19.7	21.69	22.69	8.22	Silty	Yellowish gray
D221	C1	15.1	20.53	24.33	8.90	Silty	Yellowish gray
D225	C1–2	17.3	20.25	17.78	6.32	Silty	Yellowish gray
D227	1.4–14.6	13.2	21.99	20.47	7.36	Silty	Brownish gray
D229	C1	13.6	22.88	22.86	8.30	Silty	Brownish gray
D261	0.8–10.4	9.6	26.13	23.97	8.74	Silty	Brownish gray

Modulus of Rupture

Hole No.	Sample No.	Lbs./sq. in.	Hole No.	Sample No.	Lbs./sq. in.
D161	1.2–17.6	365	D221	C1	353
D197	C1–2	402	D225	C1–2	312
D199	3.0–20.8	307	D227	1.4–14.6	319
D201	1.4–15.2	219	D229	C1	315
D220	C1	317	D261	0.8–10.4	236

SCREEN ANALYSIS*

HOLE D22, SAMPLE C1

Retained on screen	Percent	Character of residue
30	2.34	Abundance of limonitic arenaceous clay nodules; considerable quantities of quartz and ferruginous material.
60	11.25	Abundance of quartz; considerable quantity of limonitic arenaceous nodules; small amount of ferruginous material; trace of clay nodules.
100	26.30	Abundance of quartz; considerable quantity of limonitic nodules; small amounts of ferruginous material and clay nodules.
150	5.90	Abundance of quartz; considerable quantities of ferruginous material and clay nodules.
200	7.85	Abundance of limonitic and white clay nodules; considerable quantity of quartz; small amount of ferruginous material.
250	1.73	Abundance of limonitic and white clay nodules; considerable quantity of ferruginous material; small amount of quartz.
Cloth	44.63	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSIS*

HOLE D22, SAMPLE C1

Ignition loss 4.67	Iron oxide, Fe_2O_3 .. 4.71	Magnesia, MgO 0.37
Silica, SiO_2 ....69.71	Titania, TiO_2 .... 0.81	Potash, K_2O ..... Trace
Alumina, Al_2O_3 .....16.16	Lime, CaO 0.25	Soda, Na_2O 0.57

Sulphur, SO_3 .... 0.17

* Analysis of residue washed through 250 mesh screen.
M. R. Livingston, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D22, D161, D197, D199, D201, D204, D220

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D22 C1	02	28.52	15.30	1.86	2.61	–1.14	–.40	Dull red	St. H
	1	26.93	14.38	1.87	2.56	–.51	–.20	Dull red	
	3	25.48	13.44	1.90	2.55	.76	.27	Dull red	
	5	28.00	14.81	1.89	2.62	.56	.20	Dull red	
	7	29.51	15.70	1.88	2.64	.74	.27	Dull red	
	9	28.25	14.87	1.90	2.64	1.48	.50	Reddish brown	
	11	27.19	14.37	1.90	2.60	1.10	.37	Brown	
	13	25.22	13.24	1.91	2.55	2.05	.70	Brown	
D161 1.2–17.6	02	21.88	11.51	1.90	2.43	–.42	–.17	Red	St. H.
	1	22.35	11.74	1.90	2.45	–.41	–.17	Red	
	3	20.65	10.80	1.91	2.41	.81	.81	Red	
	5	25.20	13.23	1.90	2.54	.00	.00	Red	
	7	27.87	14.57	1.91	2.65	.41	.17	Red	
	9	25.23	13.00	1.94	2.60	2.02	.70	Dark red	
	11	23.10	11.63	1.99	2.59	4.32	1.49	Brown	
	13	11.86	6.03	1.98	2.25	3.65	1.25	Brown	
D197 C1–2	02	29.95	16.76	1.78	2.55	2.19	.74	Red	St. H.
	1	27.60	15.59	1.78	2.46	1.57	.54	Red	
	3	21.03	11.00	1.91	2.42	8.77	3.02	Brown	
	5	22.60	11.93	1.89	2.45	8.43	2.92	Brown	
D199 3.0–20.8	02	25.33	13.26	1.91	2.56	–1.37	–.47	Red	
	1	22.80	11.95	1.91	2.48	–1.62	–.57	Red	
	3	22.08	11.92	1.92	2.49	–1.20	–.40	Red	St. H.
	5	27.05	14.05	1.93	2.64	–1.39	–.47	Red	
	7	28.32	14.72	1.93	2.69	–1.67	–.57	Red	
	9	26.67	13.84	1.93	2.70	–.83	–.30	Dark red	
	11	28.97	14.99	1.93	2.72	–.42	–.17	Brownish red	
	13	22.79	11.79	1.93	2.49	–.41	–.17	Brown	
D201 1.4–15.2	02	25.35	13.18	1.93	2.57	–1.31	–.47	Lt. red	
	1	24.08	12.60	1.91	2.52	–1.55	–.54	Lt. red	
	3	23.26	12.05	1.93	2.51	–.56	–.20	Red	
	5	26.88	13.50	1.93	2.64	–.57	–.20	Red	
	7	28.12	14.55	1.93	2.69	–.43	–.17	Red	
	9	26.78	13.78	1.94	2.65	–.56	–.20	Red	St. H.
	11	27.67	14.33	1.93	2.67	–.28	–.10	Brown	
	13	24.43	12.69	1.93	2.55	–.30	–.10	Brown	
D204 C1	02	20.92	10.52	1.99	2.52	3.85	1.32	Red	St. H.
	1	18.85	9.23	1.99	2.51	3.79	1.28	Red	
	3	8.71	4.19	2.08	2.28	9.25	3.20	Red	
	5	18.24	8.90	2.05	2.50	7.49	2.57	Dark red	
	7	21.69	10.56	2.05	2.62	6.80	2.32	Dark red	
	9	13.38	6.62	2.02	2.34	4.92	1.70	Brown	
D220 C1	02	24.08	12.75	1.89	2.49	–1.43	–.50	Lt. red	St. H.
	1	22.85	12.15	1.88	2.44	–1.67	–.57	Lt. red	
	3	22.64	11.95	1.89	2.45	–1.23	–.44	Red	
	5	27.30	14.53	1.88	2.58	–1.88	–.64	Red	
	7	28.98	15.34	1.88	2.64	–1.42	–.50	Red	
	9	29.26	15.53	1.88	2.67	–1.62	–.57	Red	
	11	27.10	14.44	1.88	2.58	–2.17	–.74	Dark red	
	13	26.35	14.12	1.87	2.53	–2.80	–.94	Reddish brown	

Abbreviation: St. H., steel hard.

Test Holes D221, D225, D227, D229, D261

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D221 C1	02	24.95	13.13	1.90	2.53	−1.41	−.50	Red	St. H.
	1	23.33	12.30	1.90	2.48	−1.79	−.60	Red	
	3	23.33	12.21	1.91	2.49	−1.46	−.50	Red	
	5	27.55	14.51	1.90	2.62	−1.84	−.64	Red	
	7	28.63	15.08	1.90	2.66	−2.19	−.74	Red	
	9	26.84	14.14	1.90	2.59	−2.00	−.67	Dark red	
	11	27.07	14.22	1.90	2.61	−1.63	−.57	Reddish brown	
	13	26.25	13.92	1.89	2.55	−2.76	−.94	Reddish brown	
D225 C1–2	02	26.40	14.34	1.84	2.50	−1.55	−.54	Salmon	
	1	25.20	13.68	1.84	2.46	−1.76	−.60	Salmon	
	3	27.25	14.60	1.86	2.56	−1.13	−.40	Lt. red	
	5	29.35	16.05	1.83	2.58	−1.49	−.50	Lt. red	
	7	30.40	16.49	1.84	2.64	−1.53	−.54	Red	
	9	28.87	15.64	1.85	2.59	−1.14	−.40	Red	
	11	28.99	15.65	1.85	2.61	−.96	−.33	Dark red	St. H.
	13	27.00	14.48	1.87	2.56	−.79	−.27	Brownish red	
	14	26.81	14.53	1.85	2.52	−1.16	−.40	Brownish red	
D227 1.4–14.6	02	28.75	15.53	1.85	2.60	−.77	−.27	Salmon	
	1	27.61	15.00	1.85	2.55	−.78	−.27	Salmon	
	3	28.94	15.63	1.85	2.60	−.59	−.20	Lt. red	St. H.
	5	29.58	16.00	1.85	2.63	−.38	−.13	Red	
	7	32.79	17.76	1.85	2.75	−.74	−.27	Red	
	9	29.27	15.75	1.86	2.63	−.39	−.13	Red	
	11	29.95	15.79	1.89	2.70	1.36	.47	Dark red	
	13	26.86	14.31	1.88	2.58	1.38	.47	Reddish brown	
	14	25.86	13.74	1.89	2.54	1.14	.40	Reddish brown	
D229 C1	02	29.13	15.57	1.87	2.68	−1.08	−.37	Red	St. H.
	1	28.31	15.19	1.87	2.61	−1.78	−.60	Red	
	3	28.81	15.37	1.87	2.63	−.83	−.30	Red	
	5	30.08	16.17	1.87	2.66	−1.18	−.40	Red	
	7	30.25	16.12	1.88	2.69	−1.42	−.50	Red	
	9	30.23	16.13	1.87	2.68	−1.25	−.44	Red	
	11	30.42	16.33	1.86	2.67	−1.42	−.50	Dark red	
	13	28.53	15.42	1.85	2.59	−2.03	−.70	Brown	
D261 0.8–10.4	02	30.40	16.84	1.81	2.60	.00	.00	Salmon	
	1	29.49	16.45	1.80	2.54	−.43	−.17	Salmon	
	3	29.32	16.23	1.81	2.55	.60	.20	Salmon	St. H.
	5	31.50	17.43	1.81	2.63	.83	.30	Red	
	7	32.21	17.72	1.82	2.68	1.23	.44	Red	
	9	31.35	17.20	1.83	2.66	1.46	.50	Red	
	11	31.78	17.50	1.82	2.66	1.29	.44	Red	
	13	29.20	15.88	1.84	2.60	2.65	.91	Brownish red	
	14	27.82	15.07	1.85	2.56	2.73	.94	Brownish red	

Modulus of Rupture

Sample	At cone	02	1	3	5	7	9	11	13	14
D22 C1	Lbs./sq.in.	318	271	N. D.	N. D.	N. D.	585	N. D.	N. D,	
D161 1.2–17.6	Lbs./sq.in.	1172	929	1022	1150	906	1142	1207	1259	
D197 C1–2	Lbs./sq.in.	1091	1030	1016	1029					
D199 3.0–20.8	Lbs./sq.in.	492	527	644	578	752	903	800	879	
D201 1.4–15.2	Lbs./sq.in.	211	190	224	236	218	383	451	361	
D204 C1	Lbs./sq.in.	1282	1333	1470	1875	1500	2142			
D220 C1	Lbs./sq.in.	808	912	925	994	1024	1112	1145	1345	
D221 C1	Lbs./sq.in.	930	602	660	782	649	806	977	1154	
D225 C1–2	Lbs./sq.in.	446	470	552	550	566	722	692	1027	1063
D227 1.4–14.6	Lbs./sq.in.	567	517	685	665	632	696	731	1060	1190
D229 C1	Lbs./sq.in.	557	468	522	559	514	484	546	939	
D261 0.8–10.4	Lbs./sq.in.	492	413	611	557	594	708	715	835	1083

BRICK AND TILE CLAYS—SILTY

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thickness in feet	Water of plasticity in percent	Drying shrinkage		Texture	Color
				Volume in percent	Linear in percent		
D9	5.3–13.5	8.2	28.09	17.01	6.06	Fine	Grayish Cream
D14	2.2–22.0	19.8	30.97	17.35	6.17	Fine	Grayish Cream
D21	8.6–22.5	13.9	31.37	22.69	8.22	Fine	Grayish Cream
D22	C2–3	4.5	27.73	26.65	9.84	Fine	Gray
D25	2.2–27.8	25.6	26.02	21.51	7.79	Fine	Grayish Tan
D26	C1–2	8.5	25.62	22.47	8.15	Fine	Grayish Tan
D28	4.1–21.7	17.6	27.93	16.34	5.80	Fine	Grayish Cream
D164	C1–2–3	10.5	28.47	29.60	11.04	Fine	Grayish Tan
D232	1.0–14.1	13.1	32.39	39.35	15.38	Fine	Brownish Gray

MODULUS OF RUPTURE

Hole No.	Sample No.	Lbs./sq. in.	Hole No.	Sample No.	Lbs./sq. in.
D14	2.2–22.0	105	D28	4.1–21.7	104
D21	8.6–22.5	191	D164	C1–2–3	400
D25	2.2–27.8	268	D232	1.0–14.1	521

SCREEN ANALYSIS*

HOLE D22, SAMPLE C2-3

Retained on screen	Percent	Character of residue
30	0.11	Abundance of limonitic nodules; small amount of quartz; trace of gray clay nodules.
60	0.54	Abundance of limonitic nodules; considerable quantity of quartz; small amounts of white clay and gray clay nodules; plant fragments and ferruginous material.
100	1.23	Abundance of limonitic nodules; considerable quantity of white clay nodules; small amounts of quartz and ferruginous material.
150	0.50	Abundance of limonitic nodules; considerable quantity of white clay nodules; small amounts of quartz and muscovite.
200	0.84	Abundance of limonitic nodules; considerable quantity of white clay nodules; small amounts of quartz and muscovite.
250	0.52	Abundance of limonitic nodules; considerable quantity of white clay nodules; small amounts of quartz and muscovite.
Cloth	96.26	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSIS*

HOLE D22, SAMPLE C2-3

Ignition loss	6.97	Iron oxide, Fe_2O_3	2.22	Magnesia, MgO	0.92
Silica, SiO_2	65.33	Titania, TiO_2	1.07	Potash, K_2O	0.30
Alumina, Al_2O_3	21.36	Lime, CaO	0.20	Soda, Na_2O	0.97

Sulphur, SO_3 .... 0.11

* Analysis of residue washed through 250 mesh screen.

M. R. Livingston, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D9, D14, D21, D22, D25, D26

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks
D9 5.3–13.5	02	29.55	16.53	1.85	2.62	17.24	6.14	Lt. gray St. H.
	1	29.74	16.80	1.80	2.58	15.15	5.35	Lt. gray
	3	30.00	15.12	1.95	2.59	21.63	7.83	Buff
	5	26.19	13.36	1.97	2.66	22.11	8.03	Buff
	7	24.92	12.81	1.99	2.84	24.00	8.74	Buff
	9	24.50	11.99	2.04	2.70	25.10	9.18	Buff
	11	23.62	11.32	2.09	2.73	27.00	9.96	Buff
	13	13.69	6.23	2.20	2.56	30.82	11.59	Dk. buff
	14	10.97	4.88	2.25	2.52	32.32	12.24	Dk. buff
D14 2.2–22.0	02	26.86	14.90	1.93	2.65	23.85	8.70	Salmon gray St. H.
	1	23.30	11.51	2.02	2.63	26.96	9.96	Salmon gray
	3	24.08	11.26	2.12	2.56	29.02	10.83	Gray buff
	5	20.48	9.74	2.10	2.63	30.59	11.46	Gray buff
	7	17.06	8.04	2.13	2.82	31.22	11.76	Gray buff
	9	15.78	8.46	2.20	2.62	33.19	12.58	Gray buff
	11	13.22	5.84	2.27	2.61	34.91	13.38	Gray buff
	13	10.67	4.64	2.30	2.57	35.98	13.82	Brown
D21 8.6–22.5	02	27.51	14.05	1.86	2.44	13.06	4.57	Buff St. H.
	1	23.61	12.52	1.89	2.46	14.80	5.20	Buff
	3	23.82	12.84	1.98	2.42	16.72	5.95	Buff
	5	20.55	10.65	1.93	2.43	18.74	6.71	Buff
	7	17.93	9.05	1.96	2.70	19.42	6.98	Buff
	9	16.45	8.18	2.02	2.41	20.41	7.36	Buff
	11	14.37	6.47	2.05	2.38	21.70	7.83	Buff
	13	10.27	4.88	2.10	2.35	24.22	8.86	Dk. buff
	14	6.26	2.88	2.17	2.32	26.45	9.75	Gray brown
D22 C2-3	02	21.08	10.98	1.92	2.43	10.84	3.77	Salmon buff St. H.
	1	20.10	10.30	1.95	2.45	12.47	4.35	Salmon buff
	3	19.08	9.13	2.07	2.36	15.71	5.57	Salmon buff
	5	15.33	7.53	2.04	2.41	17.70	6.29	Salmon buff
	7	11.84	5.70	2.09	2.58	17.84	6.36	Salmon buff
	9	9.83	4.63	2.12	2.36	19.47	6.98	Gray
	11	9.35	4.39	2.13	2.35	19.55	7.01	Gray
	13	6.69	3.15	2.13	2.28	20.69	7.44	Gray
D25 2.2–27.8	02	23.22	12.05	1.92	2.50	14.80	5.20	Lt. gray St. H.
	1	21.41	10.95	1.96	2.49	16.70	5.91	Lt. gray
	3	21.65	10.57	2.04	2.43	19.29	6.90	Buff
	5	19.06	10.01	2.01	2.48	18.32	6.55	Buff
	7	15.73	7.70	2.05	2.61	20.38	7.32	Buff
	9	15.37	7.44	2.07	2.45	21.35	7.71	Buff
	11	13.06	6.20	2.12	2.42	22.57	8.18	Buff
	13	8.84	4.07	2.17	2.38	24.80	9.06	Brown
	14	6.80	3.07	2.22	2.37	26.21	9.67	Brown
D26 C1-2	02	23.71	11.50	2.02	2.58	17.31	6.17	Salmon buff St. H.
	1	22.07	10.97	2.04	2.53	18.33	6.55	Salmon buff
	3	19.37	9.51	2.08	2.43	19.80	7.09	Salmon buff
	5	18.59	8.96	2.08	2.55	19.42	6.98	Salmon buff
	7	14.49	6.98	2.07	2.71	19.21	6.90	Salmon buff
	9	15.20	7.14	2.13	2.51	21.78	7.87	Gray buff
	11	11.41	5.23	2.18	2.47	23.58	8.58	Gray buff
	13	9.24	4.13	2.24	2.47	25.55	9.39	Brown

TEST HOLES D28, D164, D232

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks
D28 4.1–21.7	02	31.13	17.52	1.83	2.63	12.07	4.21	Lt. gray St. H.
	1	30.03	17.00	1.78	2.58	15.00	5.27	Lt. gray
	3	30.43	16.63	1.93	2.44	19.80	7.09	Buff
	5	29.25	15.22	1.92	2.65	19.10	6.82	Buff
	7	27.67	14.44	1.97	2.82	21.25	7.67	Buff
	9	25.12	12.54	2.01	2.68	22.44	8.15	Buff
	11	24.33	12.02	2.03	2.62	23.40	8.50	Buff
	13	13.60	6.40	2.12	2.46	26.97	9.96	Brownish buff
	14	7.81	3.55	2.20	2.39	29.45	11.00	Brownish buff
D164 C1-2-3	02	19.52	9.00	2.00	2.46	15.00	5.27	Lt. gray St. H.
	1	18.44	9.20	2.00	2.43	16.23	5.76	Gray buff
	3	17.60	8.83	2.09	2.40	18.88	6.74	Gray buff
	5	14.68	7.05	2.08	2.43	18.40	6.55	Gray buff
	7	12.57	6.00	2.08	2.58	18.22	6.52	Gray buff
	9	11.90	5.63	2.11	2.40	19.46	6.98	Gray buff
	11	11.23	5.26	2.14	2.41	20.71	7.48	Gray buff
	13	9.53	4.35	2.19	2.42	22.82	8.30	Gray brown
	14	9.28	4.34	2.14	2.36	20.98	7.56	Gray brown
D232 1.0–14.1	02	16.26	7.81	2.06	2.46	18.08	6.44	Salmon buff St. H.
	1	17.42	8.58	2.03	2.46	16.78	5.96	Salmon buff
	3	15.95	7.48	2.11	2.41	20.44	7.36	Salmon buff
	5	12.00	5.68	2.16	2.39	22.06	7.99	Salmon buff
	7	9.59	4.45	2.13	2.53	20.70	7.44	Salmon buff
	9	7.96	3.68	2.17	2.35	26.76	9.88	Gray buff
	11	6.52	2.98	2.22	2.37	23.02	8.38	Gray buff
	13	3.28	1.51	2.18	2.25	23.07	8.38	Dk. gray buff
	14	16.87	8.69	1.95	2.33	13.57	4.76	Dk. gray buff

Abbreviation: St. H., steel hard.

MODULUS OF RUPTURE

Sample	At cone	02	1	3	5	7	9	11	13	14
D9 5.3–13.5	Lbs./sq.in.	812	552	825	930	1106	1347	N. D.	N. D.	N. D.
D14 2.2–22.0	Lbs./sq.in.	1075	1562	1990	2096	3107	3118	3419	2568	
D21 8.6–22.5	Lbs./sq.in.	886	1343	1766	1908	2071	3322	3403	3657	2699
D22 C2-3	Lbs./sq.in.	2104	2583	N. D.	N. D.	N. D.	4936	N. D.	N. D.	
D25 2.2–27.8	Lbs./sq.in.	1435	1562	1863	2951	3174	3570	3810	3139	3338
D26 C1-2	Lbs./sq.in.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	
D28 4.1–21.7	Lbs./sq.in.	636	784	910	1465	1459	2406	2908	2038	1782
D164 C1-2-3	Lbs./sq.in.	2002	2281	2374	2552	2631	4304	4005	3361	4091
D232 1.0–14.1	Lbs./sq.in.	2803	2828	3108	3026	3503	5129	5157	N. D.	4078

BRICK AND TILE CLAYS—CARBONACEOUS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thickness in feet	Water of plasticity in percent	Drying shrinkage Volume in percent	Drying shrinkage Linear in percent	Texture	Color
D3	C2-3	6.8	31.38	30.72	11.55	Fine	Dk. gray
D24	5.1–25.5	20.4	30.61	33.75	12.85	Fine	Brownish gray
D34	4.0–15.4	11.4	23.39	20.71	7.48	Fine	Dk. gray
D39	7.1–21.2	14.1	30.07	29.41	11.00	Fine	Dk. gray
D43	C1	8.2	29.53	34.30	13.07	Fine	Dk. gray
D98	1.8–15.4	13.6	29.39	21.55	7.79	Fine	Gray
D113	4.1–18.1	14.0	31.71	20.76	7.48	Fine	Gray
D257	4.0–16.2	12.2	27.55	25.89	9.51	Fine	Dk. gray
D260	3.1–27.0	23.9	28.34	30.12	11.29	Fine	Dk. gray

MODULUS OF RUPTURE

Hole No.	Sample No.	Lbs./sq. in.
D24	5.1–25.5	468
D34	4.0–15.4	314
D39	7.1–21.2	488
D43	C1	545

Hole No.	Sample No.	Lbs./sq. in.
D98	1.8–15.4	239
D113	4.1–18.1	155
D257	4.0–16.2	279
D260	3.1–27.0	410

SCREEN ANALYSIS*

HOLE D257, SAMPLE 4.0-16.2

Retained on screen	Percent	Character of residue
30	0.05	Abundance of limonitic arenaceous nodules; trace of quartz.
60	0.31	Abundance of limonitic nodules, considerable quantity of gray clay; small amount of quartz; trace of white clay.
100	0.75	Abundance of gray clay nodules; small amounts of quartz and white clay nodules.
150	0.45	Abundance of gray clay nodules; small amounts of quartz and white clay nodules.
200	2.90	Abundance of gray clay nodules; considerable quantity of quartz; small amount of muscovite.
250	1.04	Abundance of quartz; traces of clay, muscovite, and limonite.
Cloth	94.50	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSIS*

HOLE D257, SAMPLE 4.0-16.2

Ignition loss 6.46	Iron oxide, Fe_2O_3 .. 2.00	Magnesia, MgO 0.48
Silica, SiO_2 .... 67.56	Titania, TiO_2 .... 0.96	Potash, K_2O ....Trace
Alumina, Al_2O_3 .... 20.70	Lime, CaO 0.50	Soda, Na_2O 0.95

Sulphur, SO_3 ....Trace

* Analysis of residue washed through 250 mesh screen.

M. R. Livingston, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D3, D24, D34, D39, D43

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D3 C2-3	02	21.28	11.09	1.93	2.44	17.04	6.06	Lt. buff	St. H.
	1	19.08	9.78	1.95	2.42	18.41	6.59	Lt. buff	
	3	17.31	8.66	1.99	2.28	20.34	7.32	Lt. buff	
	5	16.34	8.18	1.99	2.39	20.25	7.28	Lt. buff	
	7	12.51	6.27	2.00	2.42	20.73	7.48	Lt. buff	
	9	13.66	6.68	2.04	2.37	21.84	7.91	Lt. buff	
	11	9.38	4.52	2.08	2.29	23.18	8.42	Lt. buff	
	13	8.46	3.97	2.13	2.33	24.11	8.82	Gray	
	14	2.58	1.19	2.17	2.23	26.66	9.84	Gray brown	
D24 5.1–25.5	02	16.50	8.02	2.06	2.43	17.75	6.32	Salmon gray	St. H.
	1	15.13	7.32	2.07	2.42	18.25	6.52	Salmon gray	
	3	11.64	5.50	2.12	2.35	20.24	7.28	Salmon gray	
	5	12.87	6.09	2.11	2.42	19.78	7.09	Salmon gray	
	7	12.71	5.89	2.18	2.41	20.99	7.56	Salmon gray	
	9	6.64	3.04	2.19	2.34	22.53	8.18	Gray buff	
	11	7.44	3.38	2.19	2.37	23.01	8.38	Gray buff	
	13	8.08	3.76	2.15	2.34	21.49	7.75	Gray brown	
D34 4.0–15.4	02	26.65	14.84	1.80	2.45	1.93	.67	Lt. buff	St. H.
	1	25.18	13.88	1.81	2.43	2.67	.91	Lt. buff	
	3	24.08	13.01	1.85	2.43	4.61	1.59	Lt. buff	
	5	26.13	14.34	1.82	2.47	3.31	1.15	Lt. buff	
	7	26.00	13.59	1.82	2.67	3.12	1.08	Lt. buff	
	9	25.04	13.34	1.87	2.51	6.16	2.11	Lt. buff	
	11	25.19	13.42	1.88	2.52	6.20	2.21	Lt. buff	
	13	23.90	12.63	1.89	2.49	7.17	2.46	Medium buff	
	14	22.03	11.59	1.90	2.45	7.33	2.53	Medium buff	
D39 7.1–21.2	02	18.24	9.50	1.98	2.42	16.37	5.80	Buff	St. H.
	1	14.84	9.23	2.02	2.38	18.16	6.48	Buff	
	3	14.62	7.35	2.06	2.36	19.51	7.01	Buff	
	5	13.49	6.58	2.05	2.38	19.43	6.98	Buff	
	7	12.69	6.18	2.07	2.57	19.05	6.82	Buff	
	9	11.88	5.57	2.14	2.42	22.58	8.18	Gray buff	
	11	8.01	3.74	2.14	2.33	22.77	8.26	Gray buff	
	13	3.53	1.66	2.15	2.21	22.98	8.34	Gray buff	
	14	14.72	7.65	1.94	2.27	14.03	4.94	Gray buff	Bl.
D43 C1	02	16.29	8.03	2.03	2.43	14.43	5.09	Buff	St. H.
	1	9.73	4.59	2.12	2.35	18.36	6.55	Buff	
	3	13.53	6.32	2.13	2.37	16.35	5.80	Buff	
	5	11.06	5.17	2.14	2.41	16.58	5.87	Buff	
	7	9.98	4.63	2.14	2.47	16.93	6.02	Buff	
	9	7.70	3.57	2.16	2.30	17.78	6.32	Gray buff	
	11	8.26	3.81	2.17	2.36	17.85	6.36	Gray buff	
	13	7.25	3.36	2.17	2.33	17.85	6.36	Gray brown	
	14	28.83	9.89	1.91	2.35	6.76	2.32	Gray brown	Bl.

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

TEST HOLES D98, D113, D257, D260

Hole No. Sample No	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D98 1.8-15.4	02	29.26	16.04	1.82	2.59	18.13	6.48	Lt gray	St. H.
	1	28.77	15.46	1.84	2.55	19.41	6.98	Lt. gray	
	3	25.14	13.08	1.98	2.53	22.21	8.07	Buff	
	5	21.83	11.13	1.93	2.57	22.65	8.22	Buff	
	7	21.00	11.01	1.92	2.79	24.67	8.40	Buff	
	9	21.38	10.53	2.02	2.57	26.37	9.71	Buff	
	11	20.40	9.84	2.07	2.60	28.16	10.45	Buff	
	13	11.21	5.04	2.22	2.51	33.60	12.76	Reddish buff	
	14	9.25	4.04	2.29	2.52	35.92	13.82	Brown	
D113 4.1-18.1	02	27.06	14.74	1.84	2.52	21.63	7.83	Lt. gray	St. H.
	1	28.61	15.57	1.84	2.57	22.00	7.95	Lt. gray	
	3	26.38	12.96	1.97	2.58	25.60	9.39	Lt. gray	
	5	24.90	12.92	1.93	2.56	27.38	10.12	Lt. gray	
	7	23.54	11.94	2.04	2.76	29.64	11.08	Buff	
	9	16.06	7.54	2.13	2.54	32.72	12.41	Buff	
	11	15.06	6.95	2.16	2.55	33.72	12.85	Buff	
	13	9.18	4.03	2.28	2.51	37.42	14.50	Gray buff	
	14	6.69	2.84	2.36	2.53	39.34	15.38	Gray buff	
D257 4.0-16.2	02	24.92	13.53	1.84	2.46	5.82	2.01	Lt. gray	St. H.
	1	24.11	13.00	1.85	2.45	6.49	2.22	Lt. gray	
	3	25.20	12.72	1.93	2.44	10.39	3.59	Lt. gray	
	5	20.61	10.65	1.98	2.41	13.09	4.57	Buff	
	7	17.37	8.75	1.98	2.65	12.53	4.39	Buff	
	9	15.25	7.53	2.02	2.39	14.56	5.12	Buff	
	11	15.05	7.43	2.03	2.38	14.66	5.16	Buff	
	13	12.72	6.08	2.09	2.23	17.37	6.17	Gray buff	
	14	7.43	3.49	2.12	2.29	18.54	6.63	Gray buff	
D260 3.1-27.0	02	23.80	11.95	1.86	2.33	5.08	1.33	Salmon gray	St. H.
	1	22.39	12.02	1.91	2.35	8.00	2.74	Salmon gray	
	3	18.37	9.59	1.99	2.35	11.64	4.06	Dull red	
	5	15.75	7.83	2.01	2.39	12.94	4.54	Dull red	
	7	15.46	7.77	2.00	2.62	11.80	4.10	Dull red	
	9	15.94	7.72	2.07	2.46	14.52	5.12	Dull red	
	11	11.34	5.59	2.12	2.39	16.83	5.98	Gray green	
	13	5.99	2.89	2.08	2.21	15.55	5.50	Red brown	
	14	12.74	7.42	1.72	1.97	-2.08	-.70	Red brown	Bl.

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

MODULUS OF RUPTURE

Sample		At cone	02	1	3	5	7	9	11	13	14
D3	C2-3	Lbs./sq.in.	2225	2251	2312	2321	2981	4448	3359	2558	N.D.
D24	5.1-25.5	Lbs./sq.in.	3327	2877	3213	3831	4130	4582	5318	N. D.	
D34	4.0-15.4	Lbs./sq.in.	989	1052	1201	1286	1593	1889	1928	2590	2673
D39	7.1-21.2	Lbs./sq.in.	3643	3802	5339	5350	5640	4646	4604	N. D.	3384
D43	C1	Lbs./sq.in.	1907	2052	2673	2713	3230	4601	5144	4544	3937
D98	1.8-15.4	Lbs./sq.in.	764	1163	1246	1406	2067	2629	2898	3394	4251
D113	4.1-18.1	Lbs./sq.in.	937	1058	1325	1414	2015	3225	3650	3760	3378
D257	4.0-16.2	Lbs./sq.in.	1697	1428	1770	2156	2187	3219	3299	3964	3529
D260	3.1-27.0	Lbs./sq.in.	2070	2282	2355	2266	2408	3121	3120	N. D.	1999

MISCELLANEOUS CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thickness in feet	Water of plasticity in percent	Drying shrinkage		Texture	Color
				Volume in percent	Linear in percent		
D1	11-31.7	20.7	28.18	18.76	6.71	Fine	Lt. gray
D5	C3	20.7	26.77	15.99	5.65	Fine	Lt. gray
D22	C8	8.9	28.58	22.11	8.03	Fine	Gray
D22	C9-10	8.8	26.72	14.75	5.20	Fine	Grayish white
D23	12.4-33.2	20.8	29.82	23.94	8.74	Fine	Gray
D26	C5	6.1	25.78	19.42	6.98	Fine	Lt. gray
D31	C4	9.0	26.75	18.75	6.71	Fine	Lt. gray
D39	21.2-36.9	15.7	24.99	12.13	4.24	Fine	Lt. gray
D171	3.8-27.8	24.0	30.15	18.27	6.52	Fine	Gray

Modulus of Rupture

Hole No.	Sample No.	Lbs./sq. in.
D1	11-31.7	180
D5	C3	106
D23	12.4-33.2	174
D39	21.2-36.9	113
D171	3.8-27.8	116

SCREEN ANALYSES*

Hole D22, Sample C8

Retained on screen	Percent	Character of residue
30	0.03	Abundance of lignitic nodules; traces of quartz, limonite, and plant fragments.
60	0.13	Abundance of quartz; considerable quantity of lignitic nodules; small amount of limonite.
100	1.69	Abundance of quartz; considerable quantities of kaolin and lignitic material; small amount of muscovite and limonite.
150	1.63	Abundance of quartz; small amounts of muscovite, lignite, kaolin, and limonite.
200	2.20	Abundance of quartz; small amounts of muscovite, lignite, kaolin, and limonite.
250	0.80	Abundance of quartz; small amounts of muscovite, lignite, kaolin, and limonite.
Cloth	93.52	Clay substance including residue from above.

HOLE D22, SAMPLE C9-10

Retained on screen	Percent	Character of residue
30	0.48	Abundance of clay "ironstones"; small amount of kaolin.
60	4.20	Abundance of clay "ironstones"; small amount of kaolin.
100	7.05	Abundance of clay "ironstones"; considerable quantity of kaolin; trace of muscovite.
150	4.10	Abundance of clay "ironstones"; considerable quantity of kaolin; small amount of muscovite.
200	5.57	Abundance of kaolin; considerable quantity of clay "ironstones"; small amount of muscovite.
250	1.46	Abundance of kaolin; considerable quantity of clay "ironstones"; small amounts of muscovite and kaolinite.
Cloth	77.14	Clay substance including residue from above.

HOLE D22, SAMPLE C11

Retained on screen	Percent	Character of residue
30	10.67	Abundance of clay "ironstones" or siderite.
60	13.65	Abundance of clay "ironstones"; small amount of muscovite.
100	10.65	Abundance of clay "ironstones"; small amount of muscovite.
150	2.26	Abundance of clay "ironstones"; considerable quantity of muscovite; small amount of kaolin.
200	2.09	Abundance of muscovite; considerable quantity of clay "ironstones"; small amount of kaolin.
250	.65	Abundance of muscovite; small amounts of clay "ironstones" and kaolin.
Cloth	60.03	Clay substance including residue from above.

HOLE D26, SAMPLE C5

Retained on screen	Percent	Character of residue
30	0.01	Small amounts of white clay and limonitic nodules.
60	0.13	Abundance of muscovite; considerable quantities of kaolin and limonitic nodules; trace of ferruginous material.
100	0.53	Abundance of muscovite; considerable quantity of kaolin; small amount of limonitic nodules; trace of kaolinite.
150	0.48	Abundance of muscovite; small amounts of quartz and kaolin; trace of biotite and limonitic nodules.
200	2.08	Abundance of muscovite; small amount of kaolin; trace of limonitic nodules.
250	0.95	Abundance of quartz; considerable quantity of muscovite.
Cloth	95.98	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSES*

HOLE D22, SAMPLE C8

Ignition loss	11.18	Iron oxide, Fe_2O_3	1.35	Magnesia, MgO	0.34
Silica, SiO_2	50.36	Titania, TiO_2	1.87	Potash, K_2O	Trace
Alumina, Al_2O_3	33.70	Lime, CaO	0.18	Soda, Na_2O	0.60
Sulphur, So_3	0.13				

HOLE D22, SAMPLE C9-10

Ignition loss	13.19	Iron oxide, Fe_2O_3	4.62	Magnesia, MgO	0.27
Silica, SiO_2	39.67	Titania, TiO_2	1.83	Potash, K_2O	Trace
Alumina, Al_2O_3	38.81	Lime, CaO	0.38	Soda, Na_2O	0.65
Sulphur, SO_3	0.21				

HOLE D22, SAMPLE C11

Ignition loss	11.31	Iron oxide, Fe_2O_3	3.80	Magnesia, MgO	0.47
Silica, SiO_2	44.77	Titania, TiO_2	1.26	Potash, K_2O	0.10
Alumina, Al_2O_3	35.40	Lime, CaO	0.11	Soda, Na_2O	1.71
Sulphur, SO_3	0.17				

HOLE D26, SAMPLE C5

Ignition loss	6.36	Iron oxide, Fe_2O_3	1.43	Magnesia, MgO	0.55
Silica, SiO_2	66.43	Titania. TiO_2	0.97	Potash, K_2O	Trace
Alumina, Al_2O_3	23.45	Lime, CaO	0.57	Soda, Na_2O	0.22
Sulphur, SO_3	Trace				

* Analyses of residue washed through 250 mesh screen.

M. R. Livingston, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D1, D5, D22, D23

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D1 11–31.7	02	27.61	14.74	1.87	2.59	18.89	6.74	Lt. grayish cream	St. H.
	1	26.50	14.06	1.89	2.57	19.40	6.94	Lt. grayish cream	
	3	23.24	11.72	1.90	2.48	22.84	8.30	Lt. grayish cream	
	5	22.31	10.89	1.98	2.57	25.00	9.14	Lt. grayish cream	
	7	18.75	8.99	2.04	2.63	25.58	9.39	Lt. grayish cream	
	9	18.06	8.89	2.08	2.56	27.05	10.00	Lt. grayish cream	
	11	17.05	8.22	2.14	2.59	28.90	10.35	Lt. grayish cream	
	13	10.89	4.89	2.22	2.50	31.75	11.98	Buff, specked	
	14	6.16	2.74	2.25	2.40	32.60	12.32	Buff, specked	
D5 C–3	02	29.53	16.45	1.80	2.54	12.35	4.32	Lt. grayish cream	St. H.
	1	27.87	14.16	1.83	2.54	14.36	5.05	Lt. grayish cream	
	3	28.98	14.96	1.90	2.48	16.94	6.02	Lt. grayish cream	
	5	26.10	13.95	1.87	2.53	17.44	6.21	Lt. grayish cream	
	7	23.19	12.22	1.93	2.71	18.63	6.67	Lt. grayish cream	
	9	22.64	11.48	1.97	2.55	20.35	7.32	Lt. greenish cream	
	11	19.42	9.54	2.04	2.53	22.65	8.22	Lt. greenish cream	
	13	11.39	5.39	2.12	2.39	25.75	9.47	Buff, specked	
	14	7.91	3.65	2.17	2.35	27.65	10.25	Buff, specked	
D22 C8	02	24.23	12.51	1.94	2.56	19.88	7.13	Lt. grayish cream	St. H.
	1	23.67	12.12	2.00	2.55	20.58	7.40	Lt. grayish cream	
	3	22.28	10.60	1.96	2.56	23.14	8.42	Lt. grayish cream	
	5	21.10	10.56	2.09	2.56	24.55	8.98	Lt. grayish cream	
	7	18.40	8.80	2.07	2.65	25.98	9.55	Lt. grayish cream	
	9	16.79	7.89	2.13	2.56	27.18	10.04	Lt. grayish cream	
	11	14.64	6.69	2.14	2.56	29.26	10.91	Lt. grayish cream	
	13	8.25	3.64	2.27	2.47	31.81	12.02	Grayish buff	
	14	7.24	3.20	2.27	2.45	33.20	12.58	Grayish buff	
D22 C9–10	02	32.15	18.90	1.90	2.36	21.79	7.87	Grayish cream	St. H.
	1	31.60	16.47	1.92	2.35	22.54	8.18	Grayish cream	
	3	30.07	15.63	1.93	2.45	22.72	8.26	Grayish cream	
	5	30.50	15.20	2.02	2.81	25.83	9.51	Grayish cream	
	7	28.00	13.83	2.01	2.90	26.72	9.88	Grayish cream	
	9	22.63	10.48	2.16	2.79	31.34	11.81	Grayish cream	
	11	17.77	8.00	2.22	2.72	33.67	12.80	Grayish cream	
	13	11.00	4.58	2.40	2.70	39.40	15.38	Brown	
D23 12.4–33.2	02	25.61	13.97	1.84	2.50	15.54	5.50	Lt. grayish cream	St. H.
	1	26.01	13.70	1.85	2.44	15.94	5.65	Lt. grayish cream	
	3	25.21	13.68	1.96	2.48	18.40	6.55	Lt. grayish cream	
	5	21.11	11.10	1.90	2.42	20.78	7.48	Lt. grayish cream	
	7	19.37	9.90	1.97	2.70	21.37	7.71	Lt. grayish cream	
	9	16.88	8.39	2.01	2.51	23.27	8.46	Lt. grayish cream	
	11	16.99	8.37	2.03	2.45	23.75	8.66	Lt. grayish cream	
	13	11.65	5.75	2.03	2.29	23.86	8.70	Buff	
	14	8.25	3.86	2.14	2.33	27.71	10.29	Buff	

Abbreviation: St., Steel hard.

TEST HOLES D26, D31, D39, D171

Hole No. Sample No	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D26 C5	02	26.88	14.86	1.81	2.48	5.51	1.90	Lt. grayish cream	St. H.
	1	26.05	14.50	1.80	2.43	5.56	1.90	Lt. grayish cream	
	3	25.54	13.91	1.84	2.47	7.49	2.57	Lt. grayish cream	
	5	21.38	11.03	1.94	2.46	11.07	3.85	Lt. grayish cream	
	7	19.20	9.82	1.87	2.78	12.64	4.43	Lt. grayish cream	
	9	17.66	8.85	1.99	2.43	15.68	5.53	Lt. grayish cream	
	11	15.91	7.78	2.04	2.43	17.12	6.10	Lt. grayish cream	
	13	9.35	4.34	2.15	2.37	21.55	7.79	Grayish cream	
	14	6.27	2.88	2.18	2.33	22.76	8.26	Gray	
D31 C4	02	28.25	15.22	1.86	2.59	14.21	5.01	Lt. grayish cream	St. H.
	1	26.45	14.04	1.88	2.56	15.10	5.31	Lt. grayish cream	
	3	24.86	13.19	1.89	2.51	15.66	5.53	Grayish cream	
	5	23.93	12.28	1.98	2.59	17.18	6.21	Grayish cream	
	7	20.71	9.02	1.94	2.75	19.33	6.94	Grayish cream	
	9	18.50	8.94	2.07	2.54	23.04	8.38	Grayish cream	
	11	12.88	5.91	2.18	2.50	26.74	9.88	Grayish cream	
	13	8.22	3.64	2.26	2.47	29.55	11.04	Dk. gray	
D39 21.2–36.9	02	33.46	18.62	1.80	2.71	14.41	5.09	Lt. grayish cream	St. H.
	1	29.09	15.46	1.88	2.65	18.20	6.48	Lt. grayish cream	
	3	28.03	14.23	2.02	2.61	21.96	7.95	Grayish cream	
	5	25.58	12.39	1.97	2.74	24.97	9.14	Grayish cream	
	7	22.44	11.13	2.07	2.77	25.85	9.51	Grayish cream	
	9	21.55	10.13	2.12	2.71	28.02	10.41	Grayish cream	
	11	20.76	9.66	2.16	2.74	29.42	11.00	Grayish cream	
	13	12.72	5.64	2.25	2.59	32.01	12.11	Gray, specked	
	14	7.64	3.34	2.29	2.48	33.11	12.58	Gray, specked	
D171 3.8–27.8	02	36.92	21.44	1.72	2.73	13.33	4.68	Lt. grayish cream	Cr. St. H.
	1	34.81	19.87	1.85	2.67	14.77	5.20	Lt. grayish cream	Cr.
	3	30.20	16.26	1.75	2.69	14.90	5.24	Grayish cream	Cr.
	5	25.42	12.45	2.09	2.65	26.89	9.92	Grayish cream	Cr.
	7	21.21	10.15	2.04	2.74	28.83	10.75	Grayish cream	Cr.
	9	20.78	9.75	2.13	2.70	30.06	11.25	Grayish cream	Cr.
	11	19.26	8.83	2.18	2.70	31.75	11.98	Grayish cream	Cr.
	13	9.34	4.03	2.31	2.55	35.50	13.59	Gray buff	Cr.
	14	8.25	3.54	2.33	2.54	36.24	13.96	Gray buff	Cr.

Abbreviation: St. H., steel hard; Cr., cracked.

MODULUS OF RUPTURE

Sample		At cone	02	1	3	5	7	9	11	13	14
D1	11–31.7	Lbs./sq.in.	1124	1325	1431	1844	2074	3559	2943	2422	2147
D5	C3	Lbs./sq.in.	680	739	1041	1109	1826	2099	2708	1828	N. D.
D22	C8	Lbs./sq.in.	1774	N. D.	N. D.	N. D.	N. D.	2629	N. D.	N. D.	N. D.
D22	C9-10	Lbs./sq.in.	838	909	668	N. D.	N. D.	2048	3379	N. D.	
D23	12.4–33.2	Lbs./sq.in.	1111	1421	1562	1921	2756	2873	3798	3850	4418
D26	C5	Lbs./sq.in.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.
D31	C4	Lbs./sq.in.	1010	1003	1463	2814	N. D.	3312	N. D.	N. D.	
D39	21.2–36.9	Lbs./sq.in.	853	817	912	1238	1382	2062	3064	1921	1824
D171	3.8–27.8	Lbs./sq.in.	182	284	358	510	513	1266	1358	1401	1973

HIGH ALUMINA CLAYS—LOW IRON

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thick-ness in feet	Water of plasticity in percent	Drying shrinkage		Texture	Color
				Volume in percent	Linear in percent		
D33	4.9–15.1	10.2	34.16	10.55	3.67	Fine	Cream
D34	15.4–36.8	21.4	29.75	12.96	4.54	Fine	Lt. gray
D91	C1	9.4	31.26	11.74	4.10	Fine	Cream
D98	15.4–38.3	22.9	35.59	14.26	5.01	Fine	Cream
D128	C4	10.0	30.23	15.06	5.31	Fine	Lt. gray
D137	C1	6.5	37.69	11.64	4.06	Fine	Cream
D137	C2	2.1	29.93	5.59	1.90	Fine	Cream
D156	C1	7.0	32.13	12.92	4.54	Fine	Cream
D186	C1	3.2	37.62	21.85	7.91	Fine	Gray
D186	C3–4	9.9	32.79	9.25	3.20	Fine	Cream
D187	9.0–12.2	3.2	39.80	16.75	5.95	Fine	Grayish cream
D187	12.2–18.2	6.0	36.81	8.25	2.85	Fine	Cream
D257	16.2–32.5	16.3	22.34	13.13	4.61	Fine	Cream
D270	P1	9.0	29.13	9.08	3.13	Fine	Cream

Modulus of Rupture

Hole No.	Sample No.	Lbs./sq. in.	Hole No.	Sample No.	Lbs./sq. in.
D33	4.9–15.1	56	D186	C3–4	51
D34	15.4–36.8	70	D187	9.0–12.2	42
D91	C1	56	D187	12.2–18.2	39
D98	15.4–38.3	61	D257	16.2–32.5	64
D137	C1	36	D270	P1	56
D186	C1	162			

SCREEN ANALYSES*

Hole D137, Sample C1

Retained on screen	Percent	Character of residue
30	.54	Abundance of kaolin nodules with pisolitic kaolin embedded; trace of carbonaceous material.
60	2.77	Abundance of kaolin nodules; considerable quantity of pisolitic kaolin; trace of limonitic kaolin.
100	2.01	Abundance of kaolin nodules and pisolitic kaolin; trace of limonitic kaolin.
150	1.11	Abundance of kaolin nodules and pisolitic kaolin; trace of limonitic kaolin and kaolinite.
200	2.03	Abundance of kaolin nodules and pisolitic kaolin; small amounts of kaolinite and limonitic kaolin.
250	0.03	Abundance of kaolin nodules; considerable quantity of quartz; small amount of kaolinite.
Cloth	91.51	Clay substance including residue from above.

HOLE D137, SAMPLE C2

Retained on screen	Percent	Character of residue
30	7.16	Abundance of kaolin with pisolitic kaolin embedded; small amount of limonitic material.
60	21.63	Abundance of kaolin with pisolitic kaolin embedded; small amount of limonitic material; traces of biotite and ferruginous rock.
100	14.75	Abundance of kaolin with pisolitic kaolin embedded; small amount of limonitic material; traces of biotite and quartz.
150	5.32	Abundance of kaolin nodules; traces of kaolinite, limonite, and ferruginous material.
200	6.71	Abundance of kaolin nodules; small amounts of ferruginous material, limonitic material, and quartz.
250	1.84	Abundance of kaolin nodules; small amount of ferruginous material.
Cloth	42.59	Clay substance including residue from above.

HOLE D186, SAMPLE C1

Retained on screen	Percent	Character of residue
30	.07	Abundance of clay nodules; considerable quantity of gypsum; trace of lignite.
60	1.80	Abundance of clay nodules; considerable quantity of gypsum; small amount of lignite and a trace of quartz.
100	2.69	Abundance of clay nodules; considerable quantity of lignite; small amounts of quartz and gypsum.
150	1.30	Abundance of clay nodules; considerable quantities of quartz and lignite; traces of muscovite and kaolinite.
200	3.12	Abundance of clay nodules; considerable quantities of quartz and lignite; small amounts of kaolinite and muscovite.
250	1.00	Abundance of clay nodules; considerable quantity of quartz; small amount of lignite; traces of kaolinite and muscovite.
Cloth	90.82	Clay substance including residue from above.

HOLE D186, SAMPLE C3-4

Retained on screen	Percent	Character of residue
30	5.31	Abundance of kaolin nodules with pisolitic kaolin embedded; trace of limonite.
60	5.49	Abundance of kaolin nodules.
100	4.19	Abundance of kaolin nodules.
150	1.78	Abundance of kaolin nodules; small amount of quartz; trace of kaolinite.
200	2.73	Abundance of kaolin nodules; small amounts of quartz and kaolinite.
250	.93	Abundance of kaolin nodules; small amounts of quartz and kaolinite.
Cloth	79.57	Clay substance including residue from above.

HOLE D187, SAMPLE 9.0-12.2

Retained on screen	Percent	Character of residue
30	4.50	Abundance of kaolin nodules; considerable quantity of limonitic stained kaolin; small amounts of ferruginous material.
60	11.62	Abundance of limonitic stained kaolin; considerable quantity of kaolin with quartz embedded; small amounts of ferruginous material.
100	9.86	Abundance of limonitic stained kaolin; considerable quantity of kaolin; small amounts of ferruginous material.
150	4.60	Abundance of limonitic stained kaolin; considerable quantity of kaolin; small amounts of ferruginous material.
200	5.70	Abundance of limonitic stained kaolin; considerable quantity of kaolin; trace of ferruginous material.
250	1.46	Abundance of limonitic stained kaolin; considerable quantity of kaolin; trace of ferruginous material.
Cloth	62.26	Clay substance including residue from above.

HOLE D187, SAMPLE 12.2-18.2

Retained on screen	Percent	Character of residue
30	4.29	Abundance of kaolin nodules with pisolitic kaolin embedded.
60	17.30	Abundance of kaolin nodules; considerable quantity of pisolitic kaolin.
100	12.51	Abundance of kaolin nodules; trace of limonitic stain.
150	5.25	Abundance of kaolin nodules; trace of limonitic stain.
200	6.60	Abundance of kaolin nodules; trace of limonitic stain.
250	1.80	Abundance of kaolin nodules; trace of limonitic stain.
Cloth	52.25	Clay substance including residue from above.

HOLE D257, SAMPLE 16.2-32.5

Retained on screen	Percent	Character of residue
30	1.61	Abundance of kaolin nodules; trace of clay "ironstones".
60	6.95	Abundance of kaolin nodules; small amount of clay "ironstones"; trace of limonite.
100	5.99	Abundance of kaolin nodules; considerable quantity of clay "ironstones"; small amount of muscovite.
150	2.34	Abundance of kaolin nodules; considerable quantity of muscovite; small amount of siderite.
200	3.35	Abundance of kaolin nodules; considerable quantity of muscovite; small amount of siderite.
250	1.11	Abundance of kaolin nodules; small amount of muscovite; trace of siderite.
Cloth	78.65	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSES*

Hole D137, Sample C1

Ignition loss	15.78	Iron oxide, Fe_2O_3	0.87	Magnesia, MgO	0.79
Silica, SiO_2	36.56	Titania, TiO_2	2.18	Potash, K_2O	Trace
Alumina, Al_2O_3	43.09	Lime, CaO	0.79	Soda, Na_2O	0.49
Sulphur, SO_3	0.16				

Hole D137, Sample C2

Ignition loss	19.70	Iron oxide, Fe_2O_3	1.84	Magnesia, MgO	0.07
Silica, SiO_2	27.43	Titania, TiO_2	2.50	Potash, K_2O	None
Alumina, Al_2O_3	47.46	Lime, CaO	0.77	Soda, Na_2O	0.46
Sulphur, SO_3	0.27				

Hole D186, Sample C1

Ignition loss	15.30	Iron oxide, Fe_2O_3	1.09	Magnesia, MgO	0.44
Silica, SiO_2	39.81	Titania, TiO_2	1.82	Potash, K_2O	Trace
Alumina, Al_2O_3	40.57	Lime, CaO	0.53	Soda, Na_2O	0.86
Sulphur, SO_3	0.13				

Hole D186, Sample C3-4

Ignition loss	15.08	Iron oxide, Fe_2O_3	0.85	Magnesia, MgO	0.12
Silica, SiO_2	38.91	Titania, TiO_2	2.10	Potash, K_2O	Trace
Alumina, Al_2O_3	43.15	Lime, CaO	0.20	Soda, Na_2O	0.37
Sulphur, SO_3	0.09				

Hole D187, Sample 9.0-12.2

Ignition loss	18.62	Iron oxide, Fe_2O_3	1.97	Magnesia, MgO	0.30
Silica, SiO_2	28.54	Titania, TiO_2	1.47	Potash, K_2O	Trace
Alumina, Al_2O_3	47.57	Lime, CaO	0.32	Soda, Na_2O	0.62
Sulphur, SO_3	0.18				

Hole D187, Sample 12.2-18.2

Ignition loss	17.78	Iron oxide, Fe_2O_3	0.60	Magnesia, MgO	0.18
Silica, SiO_2	32.65	Titania, TiO_2	1.75	Potash, K_2O	Trace
Alumina, Al_2O_3	47.51	Lime, CaO	0.22	Soda, Na_2O	0.46
Sulphur, SO_3	0.12				

Hole D257, Sample 16.2-32.5

Ignition loss	15.78	Iron oxide, Fe_2O_3	0.87	Magnesia, MgO	0.53
Silica, SiO_2	36.57	Titania, TiO_2	2.18	Potash, K_2O	Trace
Alumina, Al_2O_3	43.10	Lime, CaO	0.79	Soda, Na_2O	0.49
Sulphur, SO_3	0.16				

* Analyses of residue washed through 250 mesh screen.

M. R. Livingston, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D33, D34, D91, D98, D128

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D33 4.9–15.1	02	42.02	25.01	1.64	2.69	21.12	7.63	White	Ch.
	1	39.85	24.70	1.64	2.69	19.75	7.01	White	Ch.
	3	37.10	21.11	1.86	2.73	26.56	9.79	White	Ch.
	5	36.86	20.94	1.76	2.80	27.03	10.00	White	Ch.
	7	31.99	17.21	1.76	2.79	27.63	10.25	White	Ch., St. H.
	9	25.32	12.23	2.07	2.78	30.31	11.38	White	Ch.
	11	21.36	9.78	2.18	2.78	40.83	16.08	White	Ch.
	13	10.13	4.36	2.32	2.59	44.65	17.92	Buff	Cr.
	14	8.35	2.49	2.39	2.60	46.50	18.82	Buff	Cr.
D34 15.4–36.8	02	36.87	22.09	1.67	2.64	14.25	5.01	White	Cr.
	1	35.08	20.69	1.70	2.61	15.94	5.65	White	Cr.
	3	34.33	19.82	1.74	2.64	17.73	6.32	White	Cr.
	5	34.14	19.26	1.78	2.70	19.92	7.17	White	Cr., St. H.
	7	32.52	16.95	1.89	2.78	25.45	9.35	White	Cr.
	9	26.86	13.50	1.99	2.72	28.49	10.58	White	Cr.
	11	23.30	11.35	2.07	2.70	30.84	11.59	White	Cr.
	13	17.03	7.92	2.15	2.59	34.11	13.02	White, specked	Ch.
	14	12.13	5.45	2.23	2.53	35.99	13.82	White, specked	Ch.
D91 C1	02	40.00	24.55	1.63	2.71	15.95	5.65	White	Ch.
	1	38.63	23.84	1.63	2.65	16.12	5.72	White	Ch.
	3	37.96	23.08	1.66	2.70	17.82	6.36	White	Ch., St. H.
	5	36.62	20.90	1.75	2.76	22.06	7.99	White	Ch.
	7	34.79	19.35	1.79	2.75	23.90	8.70	White	Ch.
	9	26.69	13.38	1.99	2.72	31.49	11.85	White	Ch.
	11	25.42	12.54	2.03	2.72	32.75	12.41	White	Ch.
	13	21.78	10.27	2.13	2.72	35.90	13.78	Lt. buff	Ch.
	14	17.14	7.76	2.21	2.67	38.27	14.87	Lt. buff	Ch.
D98 15.4–38.3	02	42.60	26.26	1.63	2.83	23.79	8.66	White	Ch.
	1	40.13	24.17	1.66	2.77	26.04	9.59	White	Ch.
	3	39.84	23.33	1.71	2.84	27.21	10.08	White	Ch.
	5	37.34	21.02	1.61	2.82	31.50	11.85	White	Ch.
	7	34.58	18.53	1.86	2.85	33.91	12.93	White	Ch., St. H.
	9	30.37	15.42	1.97	2.83	37.36	14.46	White	Ch.
	11	28.27	13.93	2.32	2.82	39.42	15.42	White	Ch.
	13	9.67	4.00	2.42	2.68	49.23	20.26	Grayish buff	Ch.
	14	5.15	1.97	2.61	2.75	52.79	22.14	Grayish buff	Ch.
D128 C4	02	34.10	19.26	1.77	2.69	21.76	7.87	White	Ch.
	1	34.87	20.22	1.73	2.66	19.98	7.17	White	Ch.
	3	31.72	17.23	1.85	2.70	24.96	9.14	White	Ch.
	5	31.62	17.15	1.85	2.71	25.30	9.27	White	Ch., St. H.
	7	25.15	12.25	2.05	2.74	32.57	12.32	White	Ch.
	9	18.51	8.50	2.17	2.67	36.36	14.00	White	Ch.
	11	18.76	8.66	2.17	2.66	36.27	13.96	White	Ch.
	13	11.30	4.93	2.29	2.58	40.03	15.70	Grayish buff	Ch.
	14	8.77	3.72	2.35	2.58	41.45	16.37	Grayish buff	Ch.

Abbreviations: Ch., checked; Cr., cracked; St. H., steel hard.

TEST HOLES D137, D156, D186

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D137 C1	02	46.78	31.55	1.48	2.80	18.36	6.55	White	Ch.
	1	44.60	29.55	1.51	2.72	19.56	7.01	White	Ch.
	3	42.80	26.67	1.60	2.80	24.30	8.86	White	Ch.
	5	41.82	25.59	1.63	2.81	26.03	9.59	White	Ch.
	7	38.27	21.31	1.79	2.91	32.61	12.37	White	Ch.
	9	31.68	16.53	1.91	2.81	36.96	14.27	White	Ch., St. H.
	11	29.17	14.60	2.00	2.82	39.47	15.42	White	Ch.
	13	19.65	8.75	2.24	2.79	46.30	18.72	Lt. gray	Ch.
	14	6.41	2.56	2.51	2.68	52.60	22.03	Lt. gray	Ch.
D137 C2	02	52.60	36.35	1.45	2.99	19.05	6.82	White	Ch.
	1	51.80	36.27	1.43	2.97	18.05	6.44	White	Ch.
	3	52.85	36.91	1.43	3.03	18.48	6.59	White	Ch.
	5	47.80	30.61	1.58	3.05	26.21	9.67	White	Ch.
	7	46.80	28.79	1.62	3.05	28.15	10.45	White	Ch.
	9	44.20	26.00	1.70	3.04	31.41	11.85	White	Ch.
	11	44.72	26.25	1.70	3.08	31.60	11.89	White	Ch.
	13	34.64	17.19	2.01	3.08	42.75	16.99	Buff, specked	Ch., St. H.
	14	25.67	11.41	2.25	3.03	48.10	19.64	Buff, specked	Ch.
D156 C1	02	39.40	24.09	1.63	2.69	16.20	5.72	White	Ch.
	1	39.85	24.78	1.61	2.68	14.63	5.16	White	Ch.
	3	35.42	20.49	1.75	2.71	21.71	7.87	White	Ch.
	5	36.87	21.40	1.72	2.72	20.30	7.28	White	Ch., St. H.
	7	27.81	13.97	1.98	2.75	31.20	11.72	White	Ch.
	9	23.32	11.09	2.13	2.78	34.60	13.20	White	Ch.
	11	20.67	9.55	2.16	2.73	36.60	14.09	White	Ch.
	13	11.98	5.23	2.29	2.61	45.63	18.42	Lt. gray	Ch.
	14	9.33	3.98	2.34	2.59	41.70	16.46	Lt. gray	Ch.
D186 C1	02	37.30	21.63	1.73	2.76	24.05	8.78	White	Cr.
	1	27.71	14.26	1.96	2.63	33.47	12.71	White	Cr., St. H.
	3	25.61	13.03	1.95	2.69	32.98	12.50	White	Cr.
	5	24.84	12.34	2.01	2.68	35.04	13.42	White	Cr.
	7	25.19	12.27	2.05	2.74	36.27	13.96	White	Cr.
	9	17.75	8.16	2.18	2.65	40.10	15.70	White	Cr.
	11	10.32	4.48	2.31	2.57	43.55	17.38	Lt. gray	Cr.
	13	6.40	2.66	2.40	2.56	45.92	18.57	Gray	Cr.
	14	6.21	2.57	2.41	2.57	46.05	18.62	Gray	Cr.
D186 C3–4	02	44.52	28.72	1.55	2.78	17.39	6.17	White	Ch.
	1	40.62	25.20	1.61	2.72	20.45	7.36	White	Ch.
	3	41.97	25.91	1.62	2.85	20.77	7.48	White	Ch.
	5	40.06	23.98	1.67	2.79	23.50	8.54	White	Ch.
	7	36.93	20.83	1.77	2.81	27.94	10.37	White	Ch.
	9	31.55	16.33	1.93	2.82	33.69	12.80	White	Ch., St. H.
	11	26.35	12.67	2.08	2.82	39.45	15.42	White	Ch.
	13	18.07	7.92	2.28	2.79	44.07	17.62	Lt. gray	Ch.
	14	9.33	3.93	2.38	2.57	46.20	18.67	Lt. gray	Ch.

Abbreviations: Ch., checked; Cr., cracked; St. H., steel hard.

TEST HOLES D187, D257, D270

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D187 9.0–12.2	02	49.90	33.23	1.54	2.96	22.00	7.95	White	Ch.
	1	46.87	29.87	1.57	2.94	25.24	9.27	White	Ch.
	3	45.25	27.70	1.63	2.98	28.27	10.50	White	Ch.
	5	45.00	27.17	1.77	2.99	29.75	11.13	White	Ch.
	7	40.95	23.15	1.70	3.01	33.92	12.93	White	Ch.
	9	39.52	21.69	1.82	3.01	35.99	13.82	White	Ch., St. H.
	11	36.32	18.38	1.98	3.02	39.48	15.42	White	Ch.
	13	8.78	3.36	2.61	2.87	55.65	23.77	Dk. buff	
	14	5.71	2.11	2.70	2.87	56.75	24.40	Dk. buff	
D187 12.2–18.2	02	54.35	37.11	1.40	2.97	19.41	6.18	White	Ch.
	1	47.08	31.15	1.51	2.86	24.37	8.90	White	Ch.
	3	50.13	32.19	1.47	2.91	22.20	8.03	White	Ch.
	5	46.20	29.47	1.57	2.92	27.49	10.16	White	Ch.
	7	45.87	28.86	1.59	2.93	27.98	10.37	White	Ch.
	9	44.60	26.77	1.66	2.97	31.05	11.68	White	Ch.
	11	39.47	22.20	1.78	2.94	35.98	13.82	White	Ch.
	13	29.17	13.75	2.08	2.94	45.67	18.42	Cream	Ch., St. H.
	14	18.79	8.00	2.35	2.90	51.75	21.59	Cream	
D257 16.2–32.5	02	42.15	26.65	1.58	2.74	13.69	4.79	White	Ch.
	1	41.10	25.90	1.59	2.70	14.18	4.98	White	Ch.
	3	40.41	24.80	1.62	2.71	16.13	6.10	White	Ch.
	5	29.10	15.06	1.93	2.73	29.65	11.08	White	Ch.
	7	30.35	16.01	1.89	2.72	28.29	10.50	White	Ch., St. H.
	9	24.15	11.65	2.07	2.73	34.79	13.29	White	Ch.
	11	22.76	10.74	2.11	2.74	35.80	13.73	White	Ch.
	13	13.26	5.88	2.26	2.61	39.99	15.66	Grayish white, specked	Ch.
	14	10.08	4.35	2.32	2.57	41.21	16.27	Grayish white, specked	Ch.
D270 P1	02	43.85	28.00	1.56	2.79	9.52	3.31	White	Ch.
	1	43.08	27.80	1.55	2.73	8.71	3.02	White	Ch.
	3	42.60	27.31	1.58	2.76	11.09	3.85	White	Ch.
	5	40.20	24.17	1.71	2.80	19.24	6.90	White	Ch.
	7	39.97	22.75	1.67	2.78	14.92	5.23	White	Ch.
	9	34.95	19.73	1.77	2.74	20.22	7.28	Lt. cream	Ch., St. H.
	11	34.17	18.44	1.85	2.82	23.75	8.66	Lt. cream	Ch.
	13	31.42	16.24	1.93	2.82	27.21	10.08	Grayish cream, specked	Ch.
	14	29.75	15.04	1.98	2.82	28.52	10.62	Grayish cream, specked	Ch.

Abbreviations: Ch., Checked; St. H., steel hard.

MODULUS OF RUPTURE

Sample	At cone	02	1	3	5	7	9	11	13	14
D33 4.9–15.1	Lbs./sq.in.	N. D.	61	N. D.	N. D.	N. D.	295	242	169	408
D34 15.4–36.8	Lbs./sq.in.	352	442	471	315	795	1710	1416	2106	2181
D91 C1	Lbs./sq.in.	105	93	111	86	325	421	395	787	798
D98 15.4–38.3	Lbs./sq.in.	N. D.	N. D.	N. D.	N. D.	N. D.	181	179	396	375
D128 C4	Lbs./sq.in.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D
D137 C1	Lbs./sq.in.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	262	168
D137 C2	Lbs./sq.in.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D
D156 C1	Lbs./sq.in.	96	95	41	85	80	197	321	N. D.	N. D.
D186 C1	Lbs./sq.in.	121	161	130	258	278	375	455	922	711
D186 C3-4	Lbs./sq.in.	N. D.	N. D.	N. D.	N. D.	61	125	285	305	240
D187 9.0–12.2	Lbs./sq.in.	N. D.	133	52	N. D.	161	634	595	706	1579
D187 12.2–18.2	Lbs./sq.in.	N. D.	30	N. D.	N. D.	92	101	302	372	N. D.
D257 16.2–32.5	Lbs./sq.in.	650	125	157	125	162	1009	1074	1305	1087
D270 P1	Lbs./sq.in.	78	72	77	86	85	477	643	958	928

HIGH ALUMINA CLAYS—LIMONITIC

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thickness in feet	Water of plasticity in percent	Drying shrinkage		Texture	Color
				Volume in percent	Linear in percent		
D6	8.6–28.4	19.8	28.20	14.63	5.16	Fine	Grayish cream
D20	6.7–18.0	11.3	31.20	9.98	3.45	Fine	Grayish cream
D31	C2–3	9.1	32.57	11.68	4.06	Fine	Grayish cream
D33	C3–4	6.8	28.40	15.52	5.50	Fine	Grayish yellow
D87	2.4–16.3	13.9	32.91	11.83	4.34	Fine	Grayish cream
D101	2.5–17.0	14.5	30.37	9.91	3.45	Fine	Grayish cream
D137	C3	5.9	32.88	9.77	3.38	Fine	Grayish cream
D164	C5–6	9.3	31.93	13.57	4.76	Fine	Grayish cream
D186	C5–6	5.8	29.99	15.72	5.57	Fine	Grayish yellow
D187	18.2–23.0	4.8	36.10	14.17	4.98	Fine	Grayish cream

Modulus of Rupture

Hole No.	Sample No.	Lbs./sq. in.
D6	8.6–28.4	78
D33	C3–4	85
D87	2.4–16.3	41
D101	2.5–17.0	40

Hole No.	Sample No.	Lbs./sq. in.
D137	C3	61
D186	C5–6	109
D187	18.2–23.0	54

SCREEN ANALYSES*

Hole D137, Sample C3

Retained on screen	Percent	Character of residue
30	10.59	Abundance of kaolin nodules; considerable quantity of limonitic kaolin nodules; small amount of ferruginous material.
60	19.18	Abundance of kaolin nodules; considerable quantity of limonitic kaolin nodules; small amount of ferruginous material.
100	8.57	Abundance of kaolin nodules; considerable quantity of limonitic material; small amount of ferruginous material.
150	3.42	Abundance of kaolin nodules; considerable quantity of limonitic kaolin; small amount of ferruginous material.
200	4.43	Abundance of kaolin nodules; considerable quantity of limonitic kaolin; small amount of ferruginous material.
250	1.38	Abundance of kaolin nodules; considerable quantity of limonitic kaolin; small amount of ferruginous material.
Cloth	52.43	Clay substance including residue from above.

HOLE D186, SAMPLE C5-6

Retained on screen	Percent	Character of residue
30	4.70	Abundnace of limonitic, arenaceous nodules; small amount of white clay nodules.
60	9.61	Abundance of limonitic, arenaceous nodules; considerable quantity of white clay nodules.
100	5.69	Abundance of white clay nodules; considerable quantities of limonitic nodules.
150	5.13	Abundance of white clay nodules; considerable quantities of limonitic nodules and quartz; small amount of muscovite.
200	4.79	Abundance of white clay nodules; considerable quantities of limonitic nodules and quartz; small amount of muscovite.
250	.42	Abundance of white clay nodules; considerable quantities of limonitic nodules and quartz; small amount of muscovite.
Cloth	69.66	Clay substance including residue from above.

HOLE D187, SAMPLE 18.2-23.0

Retained on screen	Percent	Character of residue
30	1.63	Abundance of kaolin nodules; considerable quantity of limonitic nodules; small amount of ferruginous material.
60	1.56	Abundance of kaolin nodules; considerbale quantity of limonitic nodules; small amount of ferruginous material.
100	3.30	Abundance of limonitic nodules; considerable quantity of kaolin nodules; small amount of ferruginous material.
150	1.51	Abundance of limonitic nodules; considerable quantity of limonitic nodules.
200	3.22	Abundance of limonitic nodules; considerable quantity of kaolin nodules.
250	.97	Abundance of limonitic nodules; considerable quantity of kaolin nodules.
Cloth	87.81	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSES*

Hole D137, Sample C3

Ignition loss	13.55	Iron oxide, Fe_2O_3	3.94	Magnesia, MgO	0.19
Silica, SiO_2	41.38	Titania, TiO_2	2.03	Potash, K_2O	Trace
Alumina, Al_2O_3	37.79	Lime, CaO	0.25	Soda, Na_2O	0.09

Sulphur, SO_3 .... 1.19

Hole D186, Sample C5-6

Ignition loss	11.52	Iron oxide, Fe_2O_3	7.92	Magnesia, MgO	0.45
Silica, SiO_2	42.51	Titania, TiO_2	2.18	Potash, K_2O	0.10
Alumina, Al_2O_3	34.23	Lime, CaO	0.55	Soda, Na_2O	0.75

Sulphur, SO_3 ....Trace

Hole D187, Sample 18.2-23.0

Ignition loss	13.16	Iron oxide, Fe_2O_3	4.36	Magnesia, MgO	0.15
Silica, SiO_2	39.14	Titania, Tio_2	2.12	Potash, K_2O	Trace
Alumina, Al_2O_3	39.84	Lime, CaO	0.33	Soda, Na_2O	0.82

Sulphur, SO_3 .... 0.17

* Analyses of residue washed through 250 mesh screen.

M. R. Livingston, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D6, D20, D31, D33, D87

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks
D6 8.6–28.4	02	34.15	19.77	1.73	2.62	14.93	5.27	Grayish white St. H.
	1	32.24	18.25	1.77	2.61	15.32	5.42	Grayish white
	3	28.44	15.58	1.83	2.55	17.67	6.29	Grayish white
	5	29.54	15.94	1.85	2.63	18.71	6.71	Grayish white
	7	30.81	16.23	1.90	2.74	20.87	7.52	Grayish white
	9	27.78	14.14	1.97	2.66	24.15	8.82	Grayish white
	11	25.43	13.16	1.96	2.71	23.76	8.66	Grayish white
	13	14.49	6.86	2.11	2.47	29.17	10.87	Buff, specked
	14	9.10	4.19	2.17	2.39	31.20	11.72	Buff, specked
D20 6.7–18	02	42.65	26.69	1.60	2.79	14.62	5.16	Grayish white Ch., St. H.
	1	39.87	24.60	1.62	2.70	16.11	5.72	Grayish white Ch.
	3	37.40	21.42	1.76	2.66	21.67	7.83	Grayish white Ch.
	5	35.01	18.67	1.75	2.79	22.18	8.03	Grayish white Ch.
	7	33.67	19.12	1.85	2.82	25.81	9.51	Grayish white Ch.
	9	32.60	16.04	1.95	2.83	31.94	12.06	Grayish white Ch.
	11	30.17	15.31	1.97	2.82	31.06	11.68	Grayish white Ch.
	13	23.66	11.30	2.10	2.74	35.10	13.42	Buff, specked
	14	24.42	12.09	2.02	2.67	33.29	12.63	Buff, specked
D31 C2–3	02	39.25	23.45	1.68	2.76	20.37	7.32	Grayish white Ch., St. H.
	1	35.37	20.14	1.67	2.68	25.58	9.39	Grayish white Ch.
	3	34.87	19.21	1.85	2.68	26.12	9.63	Grayish white Ch.
	5	30.40	17.39	1.78	2.76	26.87	9.92	Grayish white Ch.
	7	30.26	16.47	1.82	2.78	28.60	10.62	Grayish white Ch.
	9	21.19	9.79	2.16	2.75	39.67	15.52	Grayish white Ch.
	11	19.83	8.99	2.21	2.76	40.18	15.75	Grayish white Ch.
	13	6.90	2.89	2.39	2.57	44.76	17.97	Gray brown Ch.
	14	4.18	1.69	2.43	2.54	45.80	18.47	Gray brown Ch.
D33 C3–4	02	30.71	15.83	1.94	2.80	20.73	7.48	Salmon gray St. H.
	1	28.88	14.59	2.00	2.76	23.66	8.62	Salmon gray
	3	28.85	13.57	1.98	2.78	22.50	8.15	Salmon gray
	5	28.47	13.67	2.08	2.92	26.32	9.71	Salmon gray
	7	27.26	13.69	2.11	2.97	27.37	10.12	Salmon gray
	9	22.25	10.33	2.15	2.78	28.14	10.45	Gray buff
	11	19.13	8.46	2.26	2.80	32.42	12.28	Gray buff
	13	14.50	6.37	2.28	2.67	32.92	12.50	Gunmetal
	14	9.33	4.05	2.31	2.55	34.07	12.98	Gunmetal
D87 2.4–16.3	02	42.30	25.47	1.66	2.87	22.35	8.11	Grayish white Ch.
	1	39.25	23.16	1.69	2.80	23.93	8.74	Grayish white Ch.
	3	34.58	18.37	2.05	2.79	31.27	11.76	Grayish cream Ch., St. H.
	5	31.18	16.18	1.93	2.80	33.46	12.71	Grayish cream Ch.
	7	26.50	12.93	1.88	2.88	37.48	16.50	Grayish cream Ch.
	9	23.66	11.00	2.15	2.82	40.30	15.80	Grayish cream Ch.
	11	24.11	11.29	2.14	2.81	39.70	15.52	Grayish cream Ch.
	13	4.78	1.91	2.50	2.63	48.78	20.00	Brown, specked

Abbreviations: Ch., Checked; St. H., steel hard.

Test Holes D101, D137, D164, D186, D187

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks
D101 2.5–17.0	02	38.01	22.26	1.71	2.76	20.33	7.32	Grayish white Ch.
	1	35.20	19.42	1.83	2.70	24.73	9.06	Grayish white Ch., St. H.
	3	32.05	17.48	2.05	2.59	25.70	9.43	Grayish white Ch.
	5	26.24	12.90	1.81	2.79	33.74	12.85	Grayish white Ch.
	7	20.31	9.89	2.07	2.83	34.01	12.98	Grayish white Ch.
	9	20.43	9.25	2.21	2.78	38.20	14.82	Grayish white Ch.
	11	21.53	9.77	2.20	2.80	38.25	14.87	Grayish white Ch.
	13	5.45	2.27	2.40	2.54	43.75	17.48	Dk. buff
	14	4.28	1.73	2.47	2.58	44.85	18.02	Dk. buff
D137 C3	02	37.35	20.94	1.78	2.85	24.54	8.98	Lt. gray St. H.
	1	36.68	21.25	1.73	2.72	26.61	9.84	Lt. gray
	3	34.27	19.09	1.79	2.65	27.34	10.12	Lt. gray
	5	29.08	14.49	2.00	2.83	34.76	13.29	Lt. gray
	7	24.82	11.71	2.12	2.82	38.35	14.91	Lt. gray
	9	23.48	10.95	2.15	2.80	39.14	15.28	Lt. gray
	11	20.60	9.32	2.21	2.79	41.30	16.27	Lt. gray
	13	11.10	4.83	2.29	2.59	43.55	17.38	Brown, specked
D164 C5–6	02	41.95	25.79	1.63	2.80	16.23	5.76	Grayish white Ch.
	1	40.55	25.28	1.61	2.70	16.54	5.87	Grayish white Ch.
	3	31.61	16.69	2.17	2.51	27.97	10.37	Grayish cream Ch., St. H.
	5	27.54	13.10	1.89	2.78	36.50	14.05	Grayish cream Ch.
	7	22.90	10.70	2.14	2.78	37.42	14.50	Grayish cream Ch.
	9	19.28	8.41	2.28	2.79	40.65	15.99	Grayish cream Ch.
	11	17.12	7.50	2.28	2.75	40.50	15.89	Grayish cream Ch.
	13	5.68	2.37	2.40	2.54	43.55	17.38	Brown, specked
	14	5.12	2.06	2.49	2.62	45.65	18.42	Brown, specked
D186 C5–6	02	30.60	15.65	1.96	2.82	22.35	8.11	Dull red St. H.
	1	28.87	14.86	1.94	2.73	21.61	7.83	Dull red
	3	27.56	13.00	2.02	2.69	24.95	9.14	Dull red
	5	24.43	12.04	2.11	2.81	28.22	10.50	Dull red
	7	24.94	11.78	2.12	2.83	28.66	10.66	Dull red
	9	22.72	10.29	2.21	2.86	31.37	11.81	Dull red
	11	21.50	9.79	2.20	2.88	32.55	12.32	Brown
	13	14.91	6.42	2.32	2.73	35.25	13.51	Gunmetal
D187 18.2–23.0	02	42.34	26.19	1.62	2.81	19.44	6.98	Lt. salmon Ch.
	1	38.72	20.31	2.13	2.43	36.75	14.18	Grayish cream Ch. St. H.
	3	23.82	11.16	2.05	2.55	39.02	15.24	Grayish cream Ch.
	5	23.22	10.64	2.17	2.83	40.40	15.84	Grayish cream
	7	19.44	9.48	2.14	2.81	39.18	15.28	Grayish cream Ch.
	9	17.94	7.98	2.24	2.74	42.20	16.70	Grayish cream Ch.
	11	11.35	4.80	2.36	2.61	45.20	18.17	Grayish cream Ch.
	13	5.99	2.46	2.44	2.54	47.05	19.12	Grayish brown, specked Cr.

Abbreviations: Ch., checked; Cr., cracked; St. H., steel hard.

Modulus of Rupture

Sample	At cone	02	1	2	5	7	9	11	13	14
D6 8.6–28.4	Lbs./sq.in.	592	573	556	1283	1771	2052	2205	2303	2866
D20 6.7–18	Lbs./sq.in.	217*	163*	171*	196*	710*	698*	867*	990*	N D*
D31 C2–3	Lbs./sq.in.	N D*	N D*	N D*	N D*	N D*	N D*	N D*	N D*	ND*
D33 C3–4	Lbs./sq.in.	844	949	727	2500	2560	2560	2624	2025	N.D.
D87 2.4–16.3	Lbs./sq.in.	N D*	N D*	N D*	N D*	N D*	148*	242*	456*	
D101 2.5–17.0	Lbs./sq.in.	N D*	N D*	N D*	77*	N D*	129*	422*	374*	278*
D137 C3	Lbs./sq.in.	134	106	134	86	110	364	545	903	
D164 C5–6	Lbs./sq.in.	N D*	N D*	N D*	N D*	N D*	114	134	N D	ND
D186 C5–6	Lbs./sq.in.	571	707	1044	1500	2271	2286	2619	1791	
D187 18.2–23.0	Lbs./sq.in.	68*	86*	N D*	207*	386*	604*	608*	N D*	

* Data unreliable due to condition of test pieces.

PORTERS CREEK CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thickness in feet	Water of plasticity in percent	Drying shrinkage		Texture	Color
				Volume in percent	Linear in percent		
D182	0.0–25.0	25.0	40.07	11.55	4.03	Granular	Dk. gray
D182	25.0–50.0	25.0	46.73	31.35	11.81	Granular	Dk. gray
D185	C1	11.4	66.73	42.25	16.75	Granular	Gray
D185	C2	11.0	74.82	33.97	12.93	Granular	Gray
D185	C3	10.5	71.03	33.48	12.71	Granular	Gray
D222	C1–2–3	13.6	45.50	36.59	14.09	Silty	Yellowish gray

Modulus of Rupture

Hole No.	Sample No.	Lbs./sq. in.
D182	0.0–25.0	81
D185	C1	337
D185	C2	260
D185	C3	256
D222	C1–2–3	502

SCREEN ANALYSIS*

Hole D185, Composite of Samples C1, C2, C3

Retained on screen	Percent	Character of residue
30	13.21	Abundance of gray clay nodules, some calcareous and micaceous.
60	30.16	Abundance of gray clay nodules, some calcareous and micaceous.
100	12.60	Abundance of gray clay nodules, some calcareous and micaceous.
150	4.20	Abundance of gray clay nodules, some calcareous; traces of muscovite and limonite.
200	5.34	Abundance of clay nodules; small amounts of quartz and muscovite; trace of limonite.
250	1.35	Abundance of clay nodules; small amounts of quartz and muscovite; trace of limonite.
Cloth	33.14	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSIS*

Hole D185, Composite of Samples C1, C2, C3

Ignition loss	6.56	Iron oxide, Fe_2O_3	3.84	Magnesia, MgO	1.39
Silica, SiO_2	67.05	Titania, TiO_2	0.42	Potash, K_2O	Trace
Alumina, Al_2O_3	14.38	Lime, CaO	2.31	Soda, Na_2O	0.83

Sulphur, SO_3 .... 0.13

* Analysis of whole sample.

M. R. Livingston, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D182, D185, D222

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks	
D182 0.0–25.0	02	23.57	12.12	1.94	2.55	34.74	13.29	Brownish red	St. H.
	1	23.00	11.98	1.92	2.50	33.76	12.85	Brownish red	
	3	9.02	4.30	2.09	2.31	39.71	15.56	Reddish brown	
	5	16.56	7.87	2.04	2.45	38.10	14.78	Reddish brown	
	7	19.78	10.17	1.95	2.43	34.80	13.29	Brown	
	9	12.43	7.09	1.76	2.01	28.06	10.41	Brown	
D182 25.0–50.0	02	22.51	11.84	1.91	2.46	25.57	9.39	Lt. red	St. H.
	1	20.55	10.76	1.91	2.40	25.60	9.39	Dull red	
	3	12.13	5.93	2.05	2.34	30.74	11.55	Brownish red	
	5	13.99	6.87	2.04	2.38	30.91	11.63	Brownish red	
	7	19.50	9.68	2.02	2.50	30.00	11.21	Brownish red	
	9	9.61	4.76	2.03	2.24	30.21	11.34	Brownish red	
D185 C1	02	43.80	31.70	1.38	2.46	14.98	5.27	Salmon	
	1	39.45	27.40	1.42	2.34	17.63	6.29	Buff	
	3	41.80	29.85	1.41	2.40	16.28	5.76	Buff	
	5	40.50	26.62	1.52	2.45	23.05	8.38	Buff	
	7	38.94	26.03	1.50	2.44	21.57	7.79	Buff	
	9	29.75	17.81	1.67	2.37	28.58	10.62	Dark buff	St. H.
D185 C2	02	46.25	35.35	1.30	2.42	18.60	6.63	Salmon	
	1	44.25	33.64	1.31	2.36	19.07	6.82	Buff	
	3	43.15	31.72	1.36	2.39	21.70	7.83	Buff	
	5	40.90	28.15	1.44	2.43	26.98	9.96	Buff	
	7	42.45	30.42	1.40	2.43	24.18	8.82	Buff	
	9	29.51	17.61	1.68	2.38	36.67	14.14	Dark buff	St. H.
D185 C3	02	44.65	33.27	1.34	2.41	19.40	6.94	Salmon	
	1	42.35	31.20	1.35	2.35	20.63	7.44	Buff	
	3	39.12	27.06	1.44	2.37	25.68	9.43	Buff	
	5	34.02	26.85	1.50	2.36	30.84	11.59	Reddish buff	
	7	36.25	23.55	1.54	2.41	29.74	11.13	Reddish buff	
	9	22.79	13.94	1.78	2.31	39.35	15.38	Brown	St. H.
D222 C1–2–3	02	34.27	21.19	1.62	2.47	11.64	4.06	Salmon	St. H.
	1	32.48	20.11	1.63	2.40	11.56	4.03	Salmon	
	3	30.65	18.65	1.64	2.37	13.56	4.76	Buff	
	5	34.50	20.94	1.64	2.52	14.07	4.94	Buff	
	7	34.05	20.18	1.68	2.54	15.35	5.42	Reddish buff	
	9	21.50	11.45	1.89	2.49	23.50	8.54	Reddish buff	
	11	22.76	12.01	1.90	2.45	24.93	9.14	Brown	
	13	11.14	8.52	1.89	2.27	25.45	9.35	Brown	

Abbreviation: St. H., steel hard.

Modulus of Rupture

Sample	At cone	02	1	3	5	7	9	11	13
D182 0.0–25.0	Lbs./sq.in.	734	738	1205	1900	578	2464		
D182 25.0–50.0	Lbs./sq.in.	1954	1760	1609	1692	1928	3350		
D185 C1	Lbs./sq.in.	995	1376	658	1211	906	1125		
D185 C2	Lbs./sq.in.	816	1098	852	949	835	1017		
D185 C3	Lbs./sq.in.	850	1153	969	1080	755	1599		
D222 C1-2-3	Lbs./sq.in.	1632	2134	1313	1714	848	1511	2642	1601

CALCAREOUS CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Thickness in feet	Water of plasticity in percent	Drying shrinkage		Texture	Color
				Volume in percent	Linear in percent		
D64	C1	11.6	38.26	44.25	17.72	Silty	Greenish gray
D64	C4	10.0	30.78	28.27	10.50	Silty	Greenish gray
D65	C1	12.8	41.57	44.67	17.92	Silty	Greenish gray
D65	C2	9.4	28.94	27.51	10.21	Silty	Greenish gray
D66	2-16	14.0	31.87	37.28	14.41	Silty	Greenish gray
D67	1.3-19.7	18.4	37.94	41.06	16.18	Silty	Greenish gray
D71	2.0-13.0	11.0	38.15	38.40	14.91	Silty	Greenish gray
D72	C1	8.7	34.84	34.55	13.20	Silty	Greenish gray
D73	C1	12.3	28.11	28.42	10.58	Silty	Greenish gray

Modulus of Rupture

Hole No.	Sample No.	Lbs./sq. in.
D64	C1	610
D64	C4	453
D65	C1	674
D65	C2	451
D66	2-16	569

Hole No.	Sample No.	Lbs./sq. in.
D67	1.3-19.7	637
D71	2.0-13.0	543
D72	C1	559
D73	C1	436

SCREEN ANALYSIS*

HOLE D67 1.3-19.7

Retained on screen	Percent	Character of residue
30	0.27	Abundance of argillaceous nodules; considerable quantity of gypsum; small amounts of shell fragments and calcite; trace of fossils.
60	1.80	Abundance of argillaceous nodules and gypsum; considerable quantities of quartz and fossils.
100	6.37	Abundance of argillaceous nodules; considerable quantity of quartz; small amounts of muscovite and fossils.
150	5.77	Abundance of argillaceous nodules; considerable quantity of muscovite; small amounts of quartz and glauconite.
200	13.30	Abundance of argillaceous material; considerable quantity of quartz; small amounts of glauconite, muscovite, and shell fragments.
250	2.42	Abundance of argillaceous material; small amounts of muscovite, quartz, glauconite, and shell fragments.
Cloth	70.07	Clay substance including residue from above.

* Alta Ray Gault, technician.

CHEMICAL ANALYSIS*

HOLE D67, SAMPLE 1.3-19.7

Ignition loss	17.75	Iron oxide, Fe_2O_3	4.31	Magnesia, MgO	0.86
Silica, SiO_2	37.62	Titania, TiO_2	0.71	Potash, K_2O	0.36
Alumina, Al_2O_3	15.52	Lime, CaO	18.68	Soda, Na_2O	0.54

Sulphur, SO_3 .... 0.14

* Analysis of whole sample.

M. R. Livingston analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes D64, D65, D66, D67, D71, D72, D73

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Color and remarks
D64 C1	02	29.26	17.46	1.67	2.37	12.99	4.54	Gray buff
	1	24.33	14.08	1.73	2.28	15.98	5.65	Gray buff St. H.
	3	23.93	13.41	1.82	2.41	20.86	7.52	Gray green
	5	9.73	4.99	1.95	2.16	26.10	9.59	Gray green
D64 C4	02	38.34	23.70	1.62	2.63	6.86	2.36	Gray buff
	1	34.22	21.47	1.62	2.48	7.53	2.60	Gray buff St. H.
	3	27.67	15.49	1.82	2.53	17.88	6.39	Gray green
	5	33.18	19.19	1.73	2.59	13.42	4.72	Gray green
D65 C1	02	28.20	16.54	1.71	2.20	14.31	5.05	Gray buff
	1	23.89	14.42	1.73	2.30	14.97	5.23	Gray buff St. H.
	3	14.68	7.09	2.07	2.34	29.43	11.00	Gray green
	5	9.83	4.89	2.01	2.23	27.80	10.29	Gray green
D65 C2	02	36.23	21.69	1.67	2.61	8.01	2.78	Gray buff
	1	31.08	18.16	1.71	2.48	10.82	3.77	Gray buff St. H.
	3	23.91	12.53	1.88	2.51	19.84	7.13	Gray green
	5	17.79	8.61	2.06	2.51	26.21	9.67	Gray green
D66 2-16	02	31.62	18.65	1.69	2.47	10.46	3.63	Gray buff
	1	26.82	15.38	1.74	2.38	12.52	4.39	Gray buff St. H.
	3	17.90	9.12	1.97	2.39	23.24	8.46	Gray green
	5	27.05	13.87	1.95	2.68	22.55	8.18	Gray green
D67 3-19.7	02	27.24	15.77	1.73	2.38	16.22	5.76	Gray buff
	1	22.72	12.62	1.80	2.33	20.16	7.25	Gray buff St. H.
	3	25.09	14.01	1.79	2.37	19.35	6.94	Gray green
	5	8.94	4.35	2.01	2.22	27.57	10.21	Gray green
D71 2.0-13.0	02	31.62	19.43	1.63	2.38	17.73	6.32	Gray buff
	1	27.43	16.18	1.69	2.34	20.81	7.52	Gray buff St. H.
	3	15.35	7.61	2.03	2.40	34.22	13.07	Gray green
D72 C1	02	34.50	22.77	1.52	2.32	11.93	4.17	Gray buff
	1	33.30	21.14	1.57	2.38	15.58	5.50	Gray buff St. H.
	3	29.43	16.89	1.74	2.47	23.73	8.66	Gray green
	5	19.83	9.46	2.08	2.58	36.38	14.00	Gray green
D73 C1	02	35.76	21.38	1.67	2.60	7.96	2.74	Gray buff
	1	32.21	18.96	1.70	2.51	9.83	3.42	Gray buff St. H.
	3	24.80	13.17	1.89	2.51	18.80	6.71	Gray green
	5	20.25	10.05	2.02	2.54	24.25	8.86	Gray green

Abbreviation: St. H., steel hard.

Modulus of Rupture

Sample	At cone	02	1	3	5
D64 C1	Lbs./sq.in.	2375	2801	2616	2183
D64 C4	Lbs./sq.in.	796	809	1057	879
D65 C1	Lbs./sq.in.	2072	2221	2421	2659
D65 C2	Lbs./sq.in.	1021	1131	1098	1643
D66 2-16	Lbs./sq.in.	1628	1603	1652	2213
D67 1.3-19.7	Lbs./sq.in.	2055	2618	2995	2451
D71 2.0-13.0	Lbs./sq.in.	2495	2163	2422	
D72 C1	Lbs./sq.in.	1949	242	2049	1989
D73 C1	Lbs./sq.in.	1025	1155	1255	1270

MARL

SCREEN ANALYSES*

Hole D183 Sample P1

Retained on screen	Percent	Character of residue
30	2.59	Abundance of argillaceous calcareous nodules; small amounts of fossils and quartz; traces of muscovite and pyrite.
60	18.31	Abundance of argillaceous calcareous nodules; considerable quantity of quartz; small amounts of glauconite, muscovite, and fossils.
100	33.51	Abundance of argillaceous calcareous nodules; considerable quantity of quartz; small amount of fossils; traces of glauconite and limonite.
150	10.00	Abundance of argillaccous, calcareous material; considerable quantity of quartz; small amounts of muscovite, fossils, and biotite.
200	9.87	Abundance of argillaceous material; small amount of quartz; traces of fossils, biotite, and muscovite.
250	1.42	Abundance of clay nodules; small amounts of quartz, muscovite, and biotite.
Cloth	24.30	Clay substance including residue from above.

Hole D207 Sample P1

Retained on screen	Percent	Character of residue
30	5.51	Abundance of argillaceous, calcareous nodules.
60	24.94	Abundance of argillaceous, calcareous nodules; small amounts of quartz and fossils.
100	31.23	Abundance of argillaceous, calcareous nodules; considerable quantity of quartz; small amount of limonitic nodules.
150	6.22	Abundance of argillaceous, calcareous nodules; small amounts of quartz and fossils; trace of limonite.
200	6.99	Abundance of argillaceous, calcareous nodules; small amounts of quartz and muscovite; trace of limonite.
250	1.67	Abundance of argillaceous, calcareous nodules; traces of quartz, muscovite, and limonite.
Cloth	23.44	Clay substance including residue from above.

HOLE D207 SAMPLE P2

Retained on screen	Percent	Character of residue
30	6.90	Abundance of argillaceous, calcareous nodules.
60	18.33	Abundance of argillaceous, calcareous nodules; small amount of fossils.
100	19.12	Abundance of argillaceous, calcareous nodules; small amounts of fossils, and quartz; trace of muscovite.
150	17.74	Abundance of argillaceous, calcareous material; small amounts of fossils and quartz.
200	11.44	Abundance of argillaceous, calcareous material; traces of quartz and fossils.
250	2.09	Abundance of argillaceous, calcareous material; considerable quantity of quartz; trace of fossils.
Cloth	24.37	Clay substance including residue from above.

* Alta Ray Gault, technician.

SAND

SCREEN ANALYSES*

Residue retained on screen in percent

Sample No.	20	30	60	100	150	200	250	Pan
D142 C1-C3	0	0.20	15.60	69.09	6.07	4.00	0.34	4.31
D143 C1-2-3	0	0.18	17.17	50.77	10.36	9.92	1.29	9.71
D146 11-36.5	0	0.67	47.18	31.87	7.91	2.24	0.11	10.02
D154 2.6-16.8	0	0.01	5.17	74.44	7.80	5.38	.44	6.76
D160 C1	0	0.01	10.62	73.98	7.56	2.54	0.33	4.97
D227 18.3-32.0	0	0.09	0.54	47.84	23.73	8.27	0.92	18.61
D261 C4	0	.07	.24	42.28	20.44	11.22	1.37	24.38
D271 2.2-25	0	0.02	0.18	16.06	25.21	20.64	2.49	35.40
D301 C1-2	0	6.40	43.31	19.09	10.01	5.27	0.65	15.27
D303 P1	0	2.27	32.34	32.15	6.40	7.64	1.62	17.58

* Alta Ray Gault, technician.

Character of residue:

The residue retained on all screens for the first eight samples listed is chiefly clear angular quartz grains. Small amounts of muscovite mica and limonitic stained clay nodules are present on most of the screens. On screens finer than 100 mesh some black mineral grains and some kaolinite crystals are present. The residue passing the 250 mesh screen appears to be clay and silt.

The residue retained on screens 30 and 60 for samples D301 C1-2 and D303 P1 is chiefly limonitic stained angular quartz. The residue retained on screens 100, 150, 200, and 250 is limonitic earthy nodules. The material passing the 250 mesh screen is heavily stained limonitic clay and silt.

POSSIBILITIES FOR UTILIZATION

SURFACE CLAYS

Clays represented by samples D22, Cl, D161 1.2-17.6, D199 3-20.8, and D221 Cl in this classification are the best for use in the manufacture of red brick. The fired color ranges from salmon red at low temperatures through several shades of clear red and into reddish brown at higher temperatures. There is little alteration of the clay on burning from cones 02 through 14 except changes in color. These clays have no appreciable shrinkage on burning and very little change in porosity and absorption. They are sufficiently plastic for making brick but are too short for other clay products. An improvement in plastic properties, a decrease in porosity and absorption, and an increase in strength could be effected by blending with the locally available plastic clays from the Fearn Springs formation which at some localities (D22) underlie the surface clays.

Clays represented by samples D201 1.4-15.2, D220 Cl, D227 1.4-15.6, D229 Cl, and D261 0.8-10.4 are similar to the above series except that they contain more sand and silt. They could be used for making an inferior brick but are better suited for blending with the more plastic clays which are locally available.

Sample D204 Cl would make a harder and stronger brick than the clays previously mentioned; however the material is from a creek bottom and could not be won economically.

Sample D197 Cl-2 represents eleven feet of silty clay lying above the Prairie Bluff marl. Other than the presence of a white scum on the burned samples, which is evidently due to soluble calcium salts, the clays would make an economical red to brown brick. The firing range is adequate and the maturing temperature is low.

BRICK AND TILE CLAYS

Both the silty and carbonaceous variety of the Fearn Springs clay have comparable physical and fired properties. They were grouped separately for the purpose of presenting the test data and to aid in identification, but insofar as their uses are concerned both groups are considered alike. Neither the amount of silt and sand, nor the amount of lignite, or carbonaceous matter, is present in sufficient quantity to affect the general characteristics of the several clays. Variation in properties between individual samples are due to varying amounts of silt, sand, and carbonaceous matter.

Typical properties of the clays are as follows: water of plasticity 29 percent, linear drying shrinkage 8-11 percent, green modulus of rupture 200-400 pounds per square inch. The chemical composition is in the range of silica 65 percent, alumina 21 percent, and iron 2 percent.

The clays burn to light-gray and buff colors at low temperatures, buff to gray-buff at higher temperatures, and dark-buff, gray, and brown at cones 11, 13 and 14. The clays become steel hard at cone 02 where the strength or modulus of rupture is approximately 2000 pounds per square inch. The strength increases to a maximum 3000-5000 pounds per square inch at cones 11 and 13 from which temperatures the clays become brittle and begin to overburn. Porosity, absorption, and shrinkage are variable factors with individual clays but are in the range that is common to heavy clay products.

The clays are especially suited for the manufacture of high grade light-colored face brick, fire-proofing, flue lining, conduit, load bearing hollow tile, salt glazed smooth and textured facing tile, building block, and silo tile. Terra cotta, faience, wall tile, and roofing tile are possibilities.

These clays generally underlie red-burning surface clays which could be blended with them for the production of many heavy clay products thus making use of the "overburden". To obtain a red-burning product the greater part of the surface clay or "overburden" could be blended with the plastic buff-burning clay. Sample D260 3.1-27.0 is an example of such a blend.

The location of these clays with respect to the Memphis, Tennessee, and north Mississippi markets and the excellent transportation facilities by highway and rail offer an opportunity for development that should not be overlooked.

MISCELLANEOUS CLAYS

Clays represented by samples D1 11-31.7, D5 C3, and D39 21.2-36.9 are more refractory than the clays classified as brick and tile clays. They are more open burning, and at high temperatures are speckled. The speckled effect on a light gray and buff background is characteristic of the highest-priced face brick and for this purpose these clays are particularly suited.

Clays represented by samples D22 C8, D23 12.4-33.2, and D26 C5 burn to clear even shades of light gray and cream over a long firing range. These burned colors are distinctive, and, consequently, the clays are suited for the manufacture of high grade face brick and similar products. Enamel brick, glazed facing tile, faience, and terra cotta are possibilities.

Clays represented by samples D22 C9-10 and D31 C4 contain considerable amounts of silt, siderite, and fine kaolin. They are of little value if used alone but could be utilized by blending with other clays. A composite of all the clays at test hole D22 would make valuable heavy clay products.

Sample D171 3.8-27.8, a composite of several clays, is unsatisfactory for burned clay products, due to the high silt content, low strength, and tendency to crack on burning.

HIGH ALUMINA CLAYS

The high alumina clays of Union County rank next to bauxite and bentonite in value per ton. Their use as a substitute for bauxite places them in the category of strategic or critical minerals. Although they are of value as a clay for ceramic uses, other possibilities accelerated by war emergency conditions (1941) point to an early development.

The material was first tested as a ceramic clay or kaolin, data for which is given in a preceding section of this report. In this respect the clays were divided into the low iron group and the limonitic group. Chemical analyses show that a great number of clays contain alumina (Al_2O_3) in excess of that common to kaolin or the mineral kaolinite. Thermal dehydration data indicates that the mineral gibbsite (bauxite) is also present in sufficient amounts to account for the excess of alumina. Gibbsite on heating loses its water of crystallization between the temperatures of 200° C. and 300° C. and kaolinite loses most of its water of crystallization between 450° C. and 600° C. The amount of water lost in these heat ranges is an index to the amount of kaolinite and gibbsite present in the mixture. The determination is not strictly quantitative but is probably as accurate as any other method.

The high alumina clays from test hole D137 were subjected to thermal analyses. Their thermal dehydration curves illustrate the gradation of gibbsite and kaolinite in the same deposit and further indicate that sample C1 is composed of 13.5 percent gibbsite and 82.0 percent kaolinite, sample C2, 39 percent gibbsite and 57 percent kaolinite, and sample C3, 80 percent kaolinite and little, if any, gibbsite. The remainder of sample C3 is iron oxide, mica, and quartz.

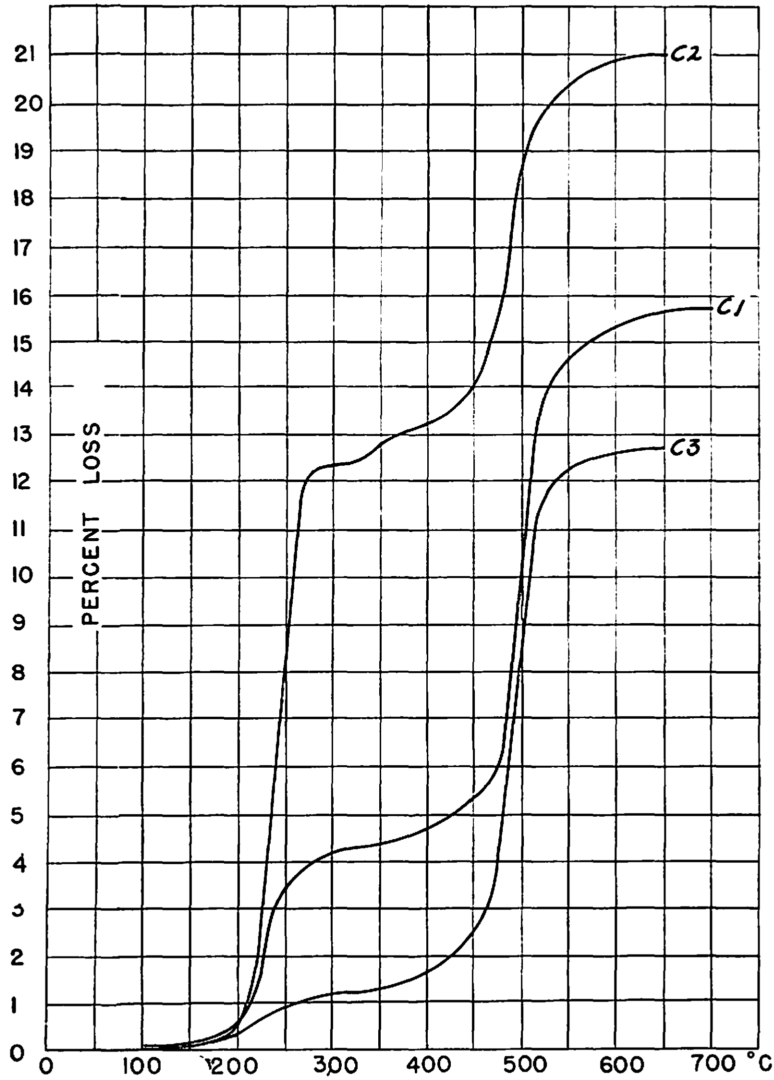


Figure 14.—Thermal dehydration curves, Samples C1, C2, and C3 from test hole D137.

Chemical analyses of seven typical samples in the low iron group show the alumina content to vary between 40.57 percent 47.51 percent or to average 44.63 percent. Fourteen samples represent a total thickness of 137 feet, and from every indication the weighted average would be over 40 percent alumina and less than 2 percent iron oxide.

Up to the present time (December 1941) no commercial process has been developed that is suitable for the extraction of alumina from clays. Such processes are being attempted by federal, state, and private research organizations which, if successful, will create a demand for high alumina clays for the production of aluminum metal. The Union County clays are in the T.V.A. region, are unusually high in alumina and low in iron, and could be utilized in a successful process for the production of alumina and the metal. While such processes are being developed, the high alumina clays that are low in iron could be utilized in the production of aluminum salts, artificial mullite and abrasives, thus reducing the shortage of bauxite which is now the sole ore of aluminum.

According to the Minerals Yearbook Review of 1940, 18 percent of the total tonnage of domestic bauxite is consumed by the chemical industry—an amount representing only 58 percent of its total consumption, the remainder being imported. In addition, 8,047 tons of alumina (Al_2O_3) and 2,076 tons of aluminum metal were used by the chemical industry in 1940.

It was determined in the laboratory of the Mississippi Geological Survey that the high alumina clays of Union County would respond to acid treatment in much the same manner as bauxite. The following table is a summary of tests using 48 percent sulfuric acid refluxed for one hour.

Sample	Total Al_2O_3	Total Fe_2O_3	Soluble Al_2O_3	Soluble Fe_2O_3	Available Al_2O_3
D137 C1	43.09	0.87	39.10	0.18	90.7
D137 C2	47.46	1.84	41.00	0.58	86.5
D137 C3	37.79	3.94	29.60	2.88	78.4
D187 9-12.2	47.57	1.97	41.72	1.36	87.5
D187 12.2-18.2	47.51	0.60	39.21	0.42	82.5
D187 18.2-23	39.84	4.36	22.21	4.06	55.5

M. R. Livingston, analyst.

It is evident that the greater part of the kaolinite is soluble in sulfuric acid.

From test hole D187, a sample representing the interval from 11.5 feet to 16.0 feet was calcined at low red heat and then analyzed quantitatively. The analysis is as follows:

Ignition loss 3.75	Iron oxide, Fe_2O_3 1.36	Alumina, Al_2O_3 59.95
Silica, SiO_2 ...... 33.29	Titania, TiO_2 ...... 1.36	Miscellaneous .. .29

The same sample was refluxed with 48 percent sulfuric acid for one hour with the following results: soluble alumina, Al_2O_3, 58.62 percent, soluble iron, Fe_2O_3, 1.06 percent.

Again it is evident that calcining renders more of the alumina in kaolin available to sulfuric acid; and in this instance 97.7 percent of the total alumina in the clay is soluble in sulfuric acid.

The group of high alumina clays that are low in iron are suited for the manufacture of commercial aluminum sulphate, commercial aluminum chloride and alum.

For the production of artificial mullite or sillimanite for subsequent use in refractories, chemical porcelain, and spark plugs, the high alumina clays low in iron are suitable for replacing 50 to 75 percent of the bauxite that is now commonly used.

The use of these clays, when calcined sufficiently, for grog in the manufacture of heavy duty fire brick and other refractory products is the most important ceramic possibility. The clays are not as well suited for pottery and porcelain manufacture as soft fine-grained kaolins.

An attempt was made to determine the fusion points or pyrometric cone-equivalents of samples D137 Cl, D137 C2, D186 Cl, D186 C3-4, D187 12-18, and D187 9-12. Cones from the clays were fired in the high temperature furnace to cone 33, cone 34, and cone 35, the maximum cone temperature that could be reached in the furnace. None of the clay cones had begun to bend at cone 35.

The high alumina clays in the limonitic group are so contaminated that they are probably of little value.

CALCAREOUS CLAYS

The clays from the Ripley formation, due to their high lime content and high shrinkage in both the raw and fired states, are unsatisfactory for the manufacture of ceramic products. On firing, the clays begin to melt at maturity and consequently do not have a satisfactory burning range. They probably could be used as a "flux" clay in reducing the maturing temperature of more refractory clays for the production of heavy clay products.

The clays are not high enough in lime for use alone in the production of mineral wool. However, they could be combined in the plastic state with crushed limestone or chalk and then formed into "brick" having the chemical and physical properties of typical wool rock.

PORTERS CREEK CLAYS

The clay from test hole D182, representing a 50 foot interval, is suitable for the production of common brick, drain tile, and fire proofing. The colors of burned test pieces from the lower 25 feet of the deposit are more attractive than those from the upper 25 feet.

The clay from test hole D185 is typical of the light-weight variety of the Porters Creek clay. This type of clay was discussed at some length in Bulletin 42, The Mineral Resources of Tippah County. A study of the light-weight variety of the Porters Creek clay in Tippah County suggested the use of the material as a light-weight aggregate and as a rotary drilling mud. The materials of Union County represented by samples C1, C2, and C3 of test hole D185 have similar possibilities. These clays burn to a somewhat harder and denser body than the best material from Tippah County. This difference seems to be due to the higher iron and lime content which acts as a flux during the burning.

Sample D222 C1-2-3 is suitable for the production of semi-light-weight brick and hollow tile. The material appears to be a mixture of the light-weight variety of the Porters Creek clay and plastic pottery clay. The wide range of color would be attractive in face brick and building block.

MARL

Marl is neither clay nor lime in the strictest sense but is a mixture of the two for which there is little if any commercial application. The material has been used to some extent for liming soil but is limited to local application.

SAND

The sand from test holes D142, D143, D146, D154, D160, D227, D261, and D271 are light colored, fine grained, and contain clay and silt in varying amounts from 4.31 percent to 35.4 percent. The sand is too fine for use in concrete but if washed would be suitable for use in plaster.

Material from test holes D301, and D303 is a mixture of clay and sand heavily stained with limonite. The material appears to be of little commercial value but may have some application as a constituent of foundry sand.

LABORATORY PROCEDURE

PREPARATION

Samples of clay were dried between 110° C. and 120° C. Primary samples of about 200 pounds were crushed in a No. 2 jaw crusher. The crushed material was screened through a No. 20-mesh Tyler standard screen; the residue coarser than 20-mesh was ground in a burr mill until it passed the 20-mesh screen. The final bit of residue remaining on the 20-mesh screen was collected for examination. The clay which had passed the 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, thermal 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 homogeneous plastic body. The small portions were recombined in the same manner and stored in a metal-lined damp box until used for making test pieces.

FORMING OF TEST PIECES

Test pieces were of two sizes; short bars, 1 inch square by 2 inches long; long bars, 1 inch square by 7 inches long. The test pieces were made by wire-cutting bars of approximate size from the plastic mass and then pressing them in molds to the final size. The long bars were pressed by hand in a hardwood mold of the plunger type. The short bars were formed in a Patterson screw press fitted with a steel die. Each test piece was identified as to 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 100 short bars were made from each primary clay sample. Certain C samples were not large enough to make the full number of test pieces.

PLASTIC, DRY, AND WORKING PROPERTIES

Immediately on forming the short bars their plastic volume was determined in a mercury volumeter. The plastic weight was measured to .01 gram using triple beam balance. All of the test pieces were allowed to air-dry several days on slatted wooden pallets and then were oven-dried by gradually increasing the temperature of the oven from room temperature to 100° C. and 110° C. for an additional hour. After drying, the short bars were placed in dessicators, and on cooling to room temperature they were reweighed and revolumed. The 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 test pieces. Clays having a suitable plasticity were formed into pottery shapes by throwing on a potters wheel. Where the quantity of clay permitted, standard size brick were made in a hand mold for the purpose of observing drying characteristics of thick bodies. The water of plasticity, modulus of rupture, and volume of shrinkage were calculated by methods outlined for the American Ceramic Society. The linear shrinkage was calculated from the volume shrinkage and checked against the linear shrinkage measured from the long bars.

FIRED PROPERTIES

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

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

After 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 dessicators and weighed to an accuracy of .01 gram on a triple beam balance. After weighing, the bars were placed in water which was then heated to the boiling point and 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 cone temperature indicated in the table of pyro-physical properties. Three short bars were fired as test pieces for each clay and at each cone.

CHEMICAL ANALYSES

Grinding: The samples which were completely analyzed were ground to pass a 100-mesh sieve. Some of the samples were washed through a 250-mesh sieve; the portion that passed through was dried, ground, and analyzed.

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

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

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

Alumina: Alumina, iron, and titania were precipitated together by ammonium hydroxide in the presence of ammonium chloride. Macerated filter paper was added to give a fine-grain precipitate. Double precipitations were found necessary to remove all manganese, calcium, and magnesium. The mixed hydroxides were filtered off, washed free of chlorides, ignited, and weighed. The weight represents the total of alumina, iron oxide, and titania. The mixed oxides were fused with sodium bisulfate to which a little sodium sulfate had been added to reduce sputtering. The fusion was dissolved in dilute sulfuric acid. In a few cases small amounts of silica were recovered here by filtration, ignition, and volatilization with hydrofluoric acid; accordingly, this was added to silica and deducted from alumina.

Iron oxide: An aliquot of the solution of the bisulfate fusion was reduced with test lead, and titrated with potassium dichromate with diphenlyamine indicator. The dichromate was standardized so that the percentage of ferric oxide in the original sample was equal to the number of cc. of solution used.

Titania: Another aliquot of the bisulfate fusion solution was placed in a colorimeter tube, and hydrogen peroxide added. The colorimeter was of the Schreiner type: i. e., a tube within a tube. The standard titania solution was diluted so that the height of the standard column divided by the height of the unknown column gave the percentage of TiO_2 in the original sample. The total of titania and iron oxide was subtracted from the weight of the combined precipitate of alumina, iron oxide, and titania, leaving alumina.

Manganese: Manganese was determined in the filtrate from alumina determination. Unless the Carbonate fusion in the silica determination was blue no manganese determination was made. Manganese was precipitated as the dioxide from a buffered acetate solution by oxidation with bromine. The dioxide was filtered off, ignited, and weighed as Mn_3O_4.

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

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

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

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

THERMAL DEHYDRATION

Exactly 40 grams of clay were placed in a porcelain crucible and suspended in a closed electric furnace by means of a nichrome wire attached to a triple beam balance. After the apparatus was put in balance a carefully calibrated thermocouple was inserted in the furnace so that the tip of the thermocouple was inside the porcelain crucible and just above the clay. The temperature was gradually increased by means of a rheostat and held constant at each 25° C. rise in temperature until the loss in weight of the clay was counterbalanced by an adjustment of the slides of the balance beam and until the balance arm remained stationary at a particular temperature. In other words, equilibrium between temperature and loss of weight was attained at each 25° C. interval. During intervals where little weight was lost by the clay, equilibrium was reached in about thirty minutes. However, during intervals where the loss in weight was accelerating and became rapid, equilibrium was reached in two to three hours according to the behavior of the particular clay. The average total time required to dehydrate a single clay was about eight hours.

CONVERSION TABLE

CONES TO TEMPERATURES

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

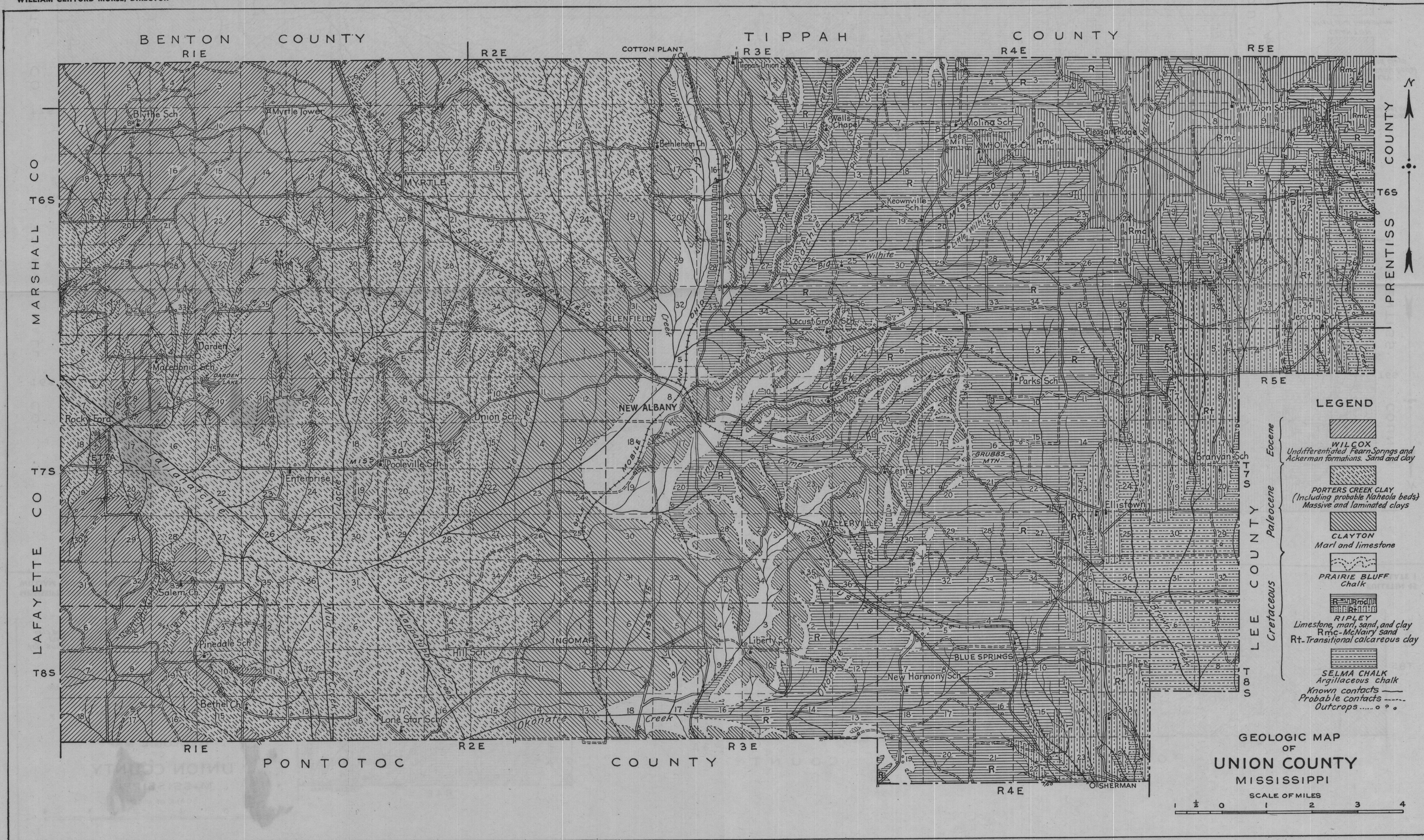
Cone No.	When heated at 100°C. per hour		Cone No.	When heated at 100°C. per hour	
	°C.	°F.		°C.	°F.
23	1,580	2,876	32	1,700	3,092
26	1,595	2,903	33	1,745	3,173
27	1,605	2,921	34	1,760	3,200
28	1,615	2,939	35	1,785	3,245
29	1,640	2,984	36	1,810	3,290
30	1,650	3,002	37	1,820	3,308
31	1,680	3,056	38	1,835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

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

PAGE REFERENCES TO TEST HOLES

MISSISSIPPI STATE GEOLOGICAL SURVEY
WILLIAM CLIFFORD MORSE, DIRECTOR

BULLETIN 45
PLATE 1



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