MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph. D.
Director

BULLETIN 38

WINSTON COUNTY MINERAL RESOURCES

GEOLOGY
By
FREDERIC FRANCIS MELLEN, M.S.

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

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1939

LETTER OF TRANSMITTAL

Office of the State Geological Survey
University, Mississippi
July 12, 1939

To His Excellency,
Governor Hugh White, Chairman, and
Members of the Geological Commission

Gentlemen:

Herewith is the manuscript of Bulletin 38, entitled Winston County Mineral Resources; the "Geology" part of which is by Frederic Francis Mellen, M.S., Assistant State Geologist, a native Mississippian and a former undergraduate and graduate student of the Director; and the "Tests" part of which is by Thomas Edwin McCutcheon, B.S., Cer. Engr., a native Georgian and a graduate Ceramic Engineer from Georgia School of Technology who has had eight years of industrial experience, and who has not only made the routine tests of the minerals but has conducted numerous research investigations of their beneficiation and new uses, as well.

The tests have been made in the laboratories of the Mississippi Geological Survey at the University of Mississippi, to which as a whole, and to the Department of Chemistry in particular, special acknowledgments are made for their splendid co-operation.

The report is possible only because of a Works Progress Administration project and grant of some $20,000.00, which were later expanded to include ten or twelve additional counties and to involve $106,193.00 of superseding Federal funds.

As sponsor and director of the geological surveys and mineral tests, the Mississippi State Geological Survey pledged $12,768.00. The State Legislature provided less than $4,000.00. The balance of $9,000.00, the counties involved are subscribing as cosponsors.

For this splendid cooperation, first on the part of Winston County, and then on the part of Tippah, Lauderdale, Yazoo, Union, Warren, and Forrest counties, the Director of the State Geological Survey wishes to express his profound appreciation, for without it, the surveys and the tests could not have been undertaken.

Personal acknowledgments have already been made in the seventeenth Biennial Report of the Mississippi Geological Survey, which, accordingly, will not be included in the Mineral Resources bulletins of each of these counties as they are published.

Respectfully submitted,

William Clifford Morse, Director

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WINSTON COUNTY MINERAL RESOURCES

GEOLOGY

FREDERIC FRANCIS MELLEN, M.S.

INTRODUCTION

Winston County lies in the east-central part of the State of Mississippi. It is bounded on the north by Oktibbeha, on the east by Noxubee, on the south by Kemper and by Neshoba, on the west by Attala, and on the north and west by Choctaw; and it is cornered with Leake on the southwest. The county is made up of 17 townships, most of which vary somewhat from the standard unit of 36 square miles; it embraces an area of 597 square miles, or 382,080 acres (17).

According to the 1930 Census the county had a population of 21,239, of which 3,013 and 526, respectively, were in the two principal settlements, Louisville, the county seat, and Noxapater.

Winston County covers portions of two major physiographic provinces, the Flatwoods and the North-Central Hills (Plateau). Here cuesta development, that is, the development in regions of gently dipping beds of asymmetrical ridges which are steep on the up-dip side and gently sloping, almost flat, on the other or dip slope side, is a prominent physiographic expression of the geology. A cuesta of the first order is made by the contact of the Midway Porters Creek clay and the Wilcox dominantly sandy or silty beds. From the crest of this cuesta the Porters Creek belt appears to the east as a vast bottom land, beyond which the slightly higher Cretaceous Black Prairie area of Noxubee County can be seen, and in the distance the Fall Line Hills (Tombigbee River Hills) in Western Alabama can be viewed distinctly against the eastern skyline. Another cuesta of the first order extends across the southwestern corner of the county where the unconsolidated sands and clays of the Wilcox series extend under the more or less indurated claystones and quartzitic sandstones of the Tallahatta formation of the Claiborne series. The boundaries of the two physiographic provinces and the limits of the two first order cuestas are made irregular and in places indefinite by the main streams and tributaries of Noxubee, Tallahaga, Lobutcha, Pinishook, Noxapater, Nanih Waiyah, and Hashuqua, which divide the area into numerous cuestas of the second and third orders.

Along the streams of the county fertile silty soils provided for the lumber industry valuable mixed timber. The most valuable forest resources are, however, practically exhausted; the clearing and cultivation of the lands have allowed extensive erosion of the friable soils and bedrock, resulting in reduction of fertility and increased hazards of overflow.

Winston County is crossed from north to south by the Gulf, Mobile, & Northern Railroad which is paralleled by the hard-surfaced State Highway 15. State Highway 14 crosses the county east to west, intersecting Highway 15 at Louisville near the center of the county. East of Louisville, Highway 14 is gravelled, but from Louisville west to the county line it has a sand-clay surface. The secondary roads are all native sand or sand-clay, with the exception of some of the roads in the Resettlement Administration area in the northern part of the county, which have been topped with crushed ferruginous sandstone or with a lateritic substance. This lateritic or bauxitic substance has proved a most satisfactory road material, not only in Winston County, but in Pontotoc County where it is used even more extensively.

The pipe line of the Southern Natural Gas Company extends diagonally from southwest to northeast across the center of Winston County. The Meridian branch line runs south along Ellison Ridge in the eastern part of the county.

The Gattman-Louisville 44 Kv. line of the Mississippi Power Company crosses from north to south almost through the center of the county, being adjacent to Highway 15 and the Gulf, Mobile, & Northern tracks from Louisville southward.

The line of the Southern Bell Telephone and Telegraph Company is adjacent to Highway 15 and the Gulf, Mobile, & Northern track through the county. A local exchange plant is in Louisville.

Because of the exhaustion of the valuable timber resources, the population depends almost entirely on agricultural pursuits, the chief crops being cotton, corn, sugar cane, and potatoes.

For a long time it has been known that Winston County has potential mineral resources, but development thus far has been limited to the production of common brick and scarified red face brick from the residual Ackerman sandy clay, and to a small and irregular output of stoneware. It was, therefore, the purpose of the present county-wide survey to make a comprehensive study of all potentially valuable clay and other mineral substances, complete insofar as funds and time permitted.

GEOLOGIC LITERATURE AND INVESTIGATIONS

Until recent work of independent oil and gas prospectors and of the present survey, no detailed geologic information had been assembled on Winston County. In the last 80 years nine or ten geologists have been in the county and have published a small amount of general information.

The first, and in some respects the most satisfactory, discussion of Winston County geology was written by Hilgard (1) in 1860. In this report he discussed in a general way the distribution of the "Flatwoods" and of the lignite-bearing beds, gave some data secured from dug wells, mentioned underground burning of the lignite, and gave a description of a fossil leaf locality.

In 1907 Crider (2) quoted from the State Chemical Laboratory an analysis of Porters Creek clay of Winston County.

In the same year Logan (3) mentioned the general geology of the county, gave an analysis of pottery clay, and described two brick plants at Louisville.

Also in 1907 Brown (4) cited Hilgard's descriptions of outcrops and described other outcrops of lignite, and quoted the State Chemical Laboratory on three analyses of lignite.

In 1909 Logan (7) discussed the geology of Winston County, described eight clay deposits, and quoted one analysis.

In 1923 P. F. Morse (8) discussed stratigraphy and economics of the bauxite and bauxitic clay and quoted one analysis from the State Chemical Laboratory.

In 1925 Burchard (9) discussed the bauxite and bauxitic clay of Winston County, giving three analyses.

In 1928 Stephenson and others (10) discussed "general features" and groundwater conditions; gave two well logs and one water analysis.

In 1933 Lowe (11) cited features of Winston County geology and gave a short discussion of the Midway-Wilcox contact.

In 1937 W. C. Morse (13) gave the geologic history and the geologic and topographic features of Legion State Park just north of Louisville, referring particularly to the land-slip topography.

In the 1920's the Gulf, Mobile, & Northern Railroad employed H. M. Payne, in the capacity of a geologist, to investigate some of the resources in Winston County. He and Mr. R. G. Brown of Louisville submitted samples of a highly arenaceous bauxitic material to a great many industrial firms and assembled much information on this substance.

In the 1920's and also in the present decade some private oil and gas work was done by consulting geologists and geophysical parties. The Independent Exploration Company made a seismographic survey of part of eastern Winston in 1937.

The three wildcat wells that have been drilled in the county penetrated part of the Wilcox, the whole of the Midway, and entered the Cretaceous strata.

Certain geologic concepts may be altered in this report, but the alterations result from a more intimate acquaintance with the facts and do not minimize the value of ideas proposed by other investigators. The unhampered use of labor has made it possible and profitable to solve some of the problems that have baffled students limited to surface examinations. Because solving geological problems has been a profitable use of labor, some of the problems and their solutions are incorporated from place to place in this report.

STRATIGRAPHIC AND AREAL GEOLOGY

In order to obtain a comprehensive idea of the mineral resources of Winston County, it was found necessary first to determine the sequence of strata and then to map the distinctive geologic units. Thus, stratigraphic and areal geology become fundamental in the prospecting of mineral resources, because knowledge of each formation, the type of beds that are found in it, the extent of variation in the beds, and the geologic distribution is necessary for tracing a known deposit into unproven territory. For instance, and there could be no better illustration, the Midway-Wilcox contact, extending in a general northwest to southeast direction across eastern Winston County, is the stratigraphic and geographic position at which the bauxite and bauxitic materials are found; eastward, and stratigraphically below this contact, no deposits of bauxite or kaolin are found, and no lignite. All of the lignite of the county is found southwest of this contact. Such generalized statements can be made only after detailed stratigraphic studies have been completed and the principal strata have been mapped areally.

CRETACEOUS BEDS

The uppermost Cretaceous formation is the Prairie Bluff chalk (14), previously known as the Oktibbeha tongue of the Selma. The Prairie Bluff formation, consisting chiefly of the "hard brittle facies" in Oktibbeha and Noxubee counties, does not crop out in Winston County but lies very near the surface in the northeastern corner. Its upper surface upon which the Eocene beds were laid down is very irregular, constituting a disconformity (Fig. 1). The Cretaceous beds, extending under the Eocene strata in the regional southwest dip, form the base upon which the younger beds were deposited. It is at this contact that commercial gas production is obtained in the Jackson gas field (15).

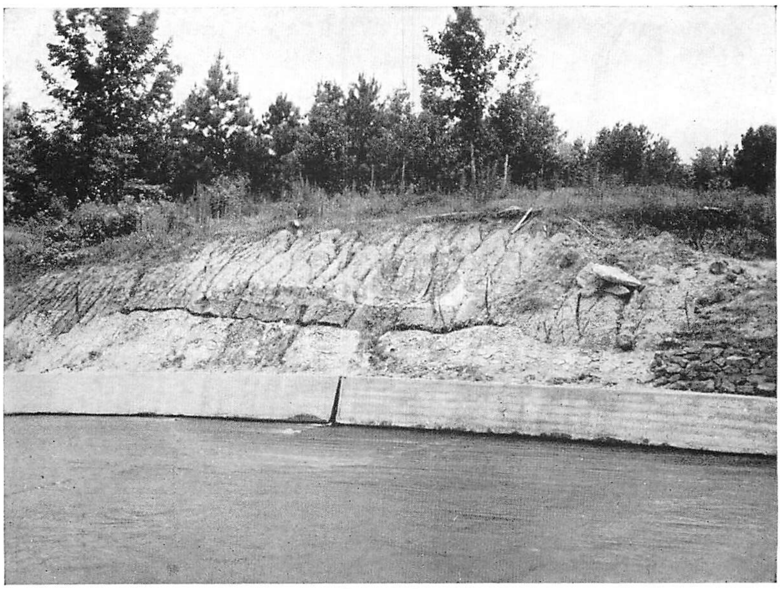


Figure 1.—Unconformities between the Prairie Bluff chalk below, the thin Clayton formation middle, and the alluvial terrace above at the spillway of Bluff Lake (NW. ¼, Lot 13, Sec. 4, T.16 N., R.15 E.), Noxubee County. The slab of stone at the right center is fossiliferous calcareous sandstone of Clayton age.---July 6, 1938.

EOCENE BEDS

MIDWAY SERIES

Clayton formation

After the deposition of the marine Prairie Bluff chalk, there was a long period of which there is left no accessible sedimentary record. During this time-interval the soft Cretaceous beds were undergoing compaction, the shoreline of the ancient gulf was retreating toward the south and southwest, and the Cretaceous beds were being lifted above sea-level and subjected to the ordinary processes of weathering and erosion (Fig. 1). After several million years, perhaps, the region sank below sea-level again, swift currents played over the shallow sea floor, removing all the ancient soil that may have existed, wearing the Cretaceous beds to an uneven surface, and depositing the abraded argillaceous chalk pebbles, silt, and fossils of Cretaceous age in a heterogeneous mixture with argillaceous, calcareous sand, and small fossils of Clayton age. Due to this unevenly worn Cretaceous surface, the thin Clayton formation is absent in parts of the outcrop area of western Noxubee County. Its thickness beneath the surface in northeastern Winston will probably exceed 8 or 10 feet in but few places, and in some places the formation will be absent as in a few localities along the outcrop in Oktibbeha and Noxubee counties.

Figure 2.—Clay typical of the middle part of the Porters Creek formation, 300 feet east of Loakfoma School (SE. 1/4, SW. 1/4, Sec. 8, T.16 N., R.14 E.).---February 14, 1938.

PORTERS CREEK FORMATION

The contact between the Clayton formation and the Porters Creek formation is not marked by an unconformity; rather, it is a gradational contact. The transition zone varies in thickness, and in most places is indicated by arenaceous, calcareous clay. The basal part of the Porters

Creek (50 feet more or less) is mostly a fine-grained silty clay containing foraminiferal shells, and enclosing erratic lenses, commonly two to four inches thick and a few feet in diameter, of sandy, glauconitic, calcareous material through which are scattered small molluscan and foraminiferal fossils.

Figure 3.—Clay typical of the upper part of the Porters Creek formation, silty laminated, containing impure siderite concretions, at spillway of Haynes Mill, now Vernons Mill (NW. ¼, Sec. 11, T.13 N., R.14 E.).---April 12, 1938.

Small marine gastropod, pelecepod, and crab fossils, are found as molds in the lower two-thirds or three-fourths of the formation, but, due to the conchoidal and hackly fracture of the clay, and possibly also to their rarity, the fossils are difficult to discover. They are present, for instance, in the highway bank at Loakfoma, 150 feet southwest of the C. J. Moorehead residence (N. ½, NW. ¼, Sec. 17, T.16 N., R.14 E.); northeast of Fearn Springs beside the road on the L. H. Fleetwood place (NE. ¼, NE. ¼, Sec. 25, T. 14 N., R. 14 E.); and near Singleton (SW. ¼, Sec. 4, T.15 N., R.14 E.). Similar fossils are found also above and below the thin highly fossiliferous lenses in the Porters Creek on Highway 14, 0.2 mile east of the county line, 4.0 miles west of Mashulaville, Noxubee County.

Above the sandy basal part of the formation are 350 to 450 feet of fine-grained slightly silty dark-gray or black carbonaceous jointed clay, which weathers to a dove-gray clay having a conchoidal fracture (Fig. 2). This part of the formation appears to be massive, but close examination reveals very fine laminae running through even the purest lumps of clay.

Figure 4.—Midway-Wilcox unconformity: silty Porters Creek clay below and gritty basal Ackerman sand above. The Betheden and Fearn Springs formations are both missing at this point, the south abutment of Andersons Mill dam (SE. ¼, SW. ¼, Sec. 2, T.13 N., R.14 E.).---February 16, 1938.

The upper 50 to 100 feet of the Porters Creek clay in Winston County are very silty, in part glauconitic, micaceous, and sandy; the clay is distinctly laminated, and in places contains beds and lenses of sand up to a foot or more in thickness. A single small piece of lignitized wood was found near the top of the formation in northern Winston. This part of the formation (Fig. 3) contains beds of silty siderite of no economic value. It is equivalent to the Naheola formation of Alabama.

Cross-bedded fine-grained micaceous sand crops out just below the sandy bauxitic clay on the public road on the J. J. Moody farm (NW. ¼, SE. ¼, Sec. 33, T.14 N., R.14 E.), and a similar sand was found in test hole 119 at Fearn Springs. This material undoubtedly is typical of the Naheola formation. There is also much argillaceous, micaceous cross-bedded and laminated sand at this position south of Perkinsville Cemetery (Sec. 4., T.14 N., R.14 E.), and on the R. G. Brown, Jr. property (SW. ¼, SE. ¼, Sec. 21, T.14 N., R.14 E.). Because within Winston County the Naheola is weakly developed, it is not regarded as a separate unit, but is included in the Porters Creek formation. Locally the Naheola equivalent has been removed by erosion and younger materials deposited in its place (Fig. 4).

Computations of the regional dip per mile, multiplied by the width of outcrop (allowing for the difference in elevation of the northeastern and southwestern contacts) give a thickness of approximately 500 feet. Another set of computations, based on the discovery of Porters Creek clay in a test hole at the intersection of the public road and the Winston-Noxubee County line, indicates a thickness of 565 feet. Logs of various deep wells penetrating the formation in Winston County seem to indicate a greater thickness. Crider (6) reported a thickness of 100 to 210 feet along the outcrop in Mississippi, Lowe (11) 200 feet or more, and Grim (16) 800 feet. Grim's figure was obtained from a deep well in central Mississippi. It is interesting, therefore, to know that the thickness along the outcrop in Winston County is comparable to the greater thicknesses reported from deep wells.

The average strike of the Eocene beds in Winston County is approximately N. 35° W.

Most geologic writers have accepted as a fact the idea that at least part of the Porters Creek clay was marine, but without citing definite proof. On the basis of collections made by the present writer and of studies made by M. L. Thompson, it is now thought that the entire formation was deposited beneath marine waters. The following samples were examined:

Sample 1, Porters Creek clay from the E. P. Rainey place (SE. ¼, SE. ¼, Sec. 27, T.16 N., R.12 E.), stratigraphically about 25.0 feet below the base of the lignite and the top of Betheden residuum;

Sample 2, Porters Creek clay from the E. P. Rainey place (NE. ¼, NW. ¼, Sec. 26, T.16 N., R.12 E.), stratigraphically 21.8 to 24.9 feet below the base of the lignite and below the top of the Betheden residuum; 37.3 feet below the flood-plain of Noxubee Creek;

Sample 3, Porters Creek clay from 1.1 miles west of Webster (near or at the intersection of Secs. 19, 20, 29, and 30, T.16 N., R.13 E.), Winston County, stratigraphically near the top of the Porters Creek, perhaps in the upper 30.0 feet of the unweathered body of the Porters Creek;

Sample 4, Porters Creek clay on the west side of the road 5.0 feet above the water of Mill Creek and 50.0 yards south of the bridge (NW. ¼, NW. ¼, Sec. 32, T.16 N., R.13 E.), Winston County; stratigraphically within 15.0 feet of the top of the formation;

Sample 5, Porters Creek clay from Highway 14, 0.9 mile west of Mashulaville, Noxubee County; elevation 255 feet;

Sample 6, Porters Creek clay from Highway 14, 2.5 miles west of Mashulaville, Noxubee County; elevation 265 feet;

Sample 7, Porters Creek clay from Highway 14, 4.0 miles west of Mashulaville and 0.2 mile east of Winston County line, Noxubee County. Sample from immediately above and below the three-inch lens of highly fossiliferous ferriferous marl. Position: approximately the middle of the Midway, 250 feet above the base; elevation 340 feet;

Sample 8, Porters Creek clay from Highway 14, 2.3 miles west of Noxubee County line, Winston County; elevation 375 feet;

Sample 9, Porters Creek clay from Highway 14, 2.5 miles west of Noxubee County line, Winston County; elevation 450 feet. This sample near center of the upper 100 feet of the Midway is sandy, ferriferous, and micaceous;

Sample 10, Porters Creek clay, represents the upper 10.0 feet below the sharp erosional unconformity (Wilcox gritty sand above); clay entirely fresh, no oxidation. Location: Winston County, at south abutment of Anderson's Mill dam (SW. ¼, Sec. 2., T.13 N., R.14 E.);

Sample 11, Porters Creek clay, from big roadside wash 300 feet east of Loakfoma School (SE. ¼, SW. ¼, Sec. 8, T.16 N., R.14 E.), Winston County. Sample approximately at or just below the middle of the Porters Creek formation, about 250 to 270 feet below the top of the formation. Sample from about 5.0 or 6.0 feet of the exposure of typical conchoidal incipiently weathered fine-grained Porters Creek clay;

Sample 12, Clayton formation 6.3 miles west of Macon courthouse, Noxubee County, on Highway 14, about 5.0 feet above the Prairie Bluff (Cretaceous) contact;

Sample 13, Porters Creek formation, transitional lower part calcareous, glauconitic silty fossiliferous clay; sample from interval about 10.0 to 25.0 feet above the Cretaceous contact, 7.4 miles west of Macon courthouse, Noxubee County, on Highway 14;

Sample 14, Porters Creek formation, about 100 to 150 feet above the Cretaceous contact, in big outcrop along the north side of Highway 14, 10.0 miles west of Macon courthouse and 2.0 miles east of Mashulaville;

Sample 15, from the C. J. Moorehead land on the Starkville Highway, opposite garden (N. ½, NW. ¼, Sec. 17, T.16 N., R.14 E.), Winston County. This sample is stratigraphically 30.0 feet above Sample 11. It is 220 to 230 feet below the top of Midway and is at or just above the middle of the Porters Creek clay. Sample contains pelecepod mold;

Sample 16, W. P. Joiner place (U. S. Resettlement Administration) on Starkville Highway about one-quarter mile south of Oktibbeha County line on roadside, 200 yards south of Noxubee Creek (Sec. 6, T.16 N., R.14 E.), Winston County. Sample 300 feet more or less below top of Porters Creek clay;

Sample 17, W. P. Joiner place (U. S. Resettlement Administration) north of Sample 16 and 25.0 feet lower, reckoned from water level of Noxubee Creek on west side of bridge, Starkville Highway (Sec. 6, T.16 N., R.14 E.), Winston County. Sample 325 feet more or less below top of Porters Creek clay.

Thompson reports:

Sample 1, No fauna observed
Sample 2, Sparse arenaceous foraminifera
Sample 3, Fairly common arenaceous foraminifera
Sample 4, Fairly common arenaceous foraminifera
Sample 5, Small fauna and rare; *Bolivina* sp., *Bulimina* sp., and arenaceous foraminifera
Sample 6, Rare *Ammobaculities* and diatoms
Sample 7, Rare *Ammobaculities*
Sample 8, Foraminifera rare; *Bolivina* 3 sp., *Spiroplectammina* sp., *Vaginulina* sp.
Sample 9, Rare arenaceous foraminifera; *Gaudryina?* sp., *Ammobaculities*
Sample 10, Rare arenaceous foraminifera; *Gaudryina?* sp., *Ammobaculities*
Sample 11, *Ammobaculities*, diatoms

Sample 12, Very abundant Clayton? foraminifera
Sample 13, Very abundant foraminifera; transitional foraminifera from basal types to typical Porters Creek types
Sample 14, Common arenaceous foraminifera
Sample 15, Fairly common arenaceous foraminifera
Sample 16, No foraminifera observed
Sample 17, *Ammobaculities*

Specific determination of the forms in this collection will be part of a broad micro-paleontological study by Thompson on the Midway beds. Thus far, he has found that calcareous foraminifera are practically limited to the basal part of the formation and that arenaceous forms are found throughout the entire formation. When completed, his studies should be of great value to commercial micro-paleontologists.

Betheden formation

The Betheden residuum or formation includes all residual material at the top of the Midway and below the Midway-Wilcox unconformity. It includes the deposits of bauxite, kaolin, bauxitic and kaolinitic clays, and the overlying lignite. Where fully preserved the entire thickness of the formation is approximately 25.0 feet. The lower contact is gradational into the Porters Creek formation. The upper contact is unconformable with the Fearn Springs, or with the Ackerman where the Fearn Springs was eroded. In many places the Betheden itself was eroded and the Wilcox beds were deposited directly upon the unaltered Midway (Fig. 4).

The type locality of the formation is at Livingston Spring (Fig. 5) at Betheden (SW. ¼, SE. ¼, Sec. 23, T.16 N., R.13 E.), where both the lignite and the ancient soil are exposed. A few score feet to the east in the bed of Dry Creek unaltered Porters Creek clay crops out. There are numerous outcrops of the residuum on the hills around Betheden.

In Winston County the Betheden formation is well-developed in the Betheden area, in the area southeast of Gum Branch, and in a north-south belt through the center of T.14 N., R.14 E.

Previous reports on the bauxite-kaolin deposits of Mississippi did not describe the precise relations with other beds. Morse (8) reported "The bauxite is in the Ackerman formation (basal Wilcox) near its contact with the Porters Creek clay of the Midway series." He did not discuss the origin of the Mississippi beds. Burchard (9), also, places the deposits in the lower Ackerman. He did not consider them the product of the sub-aerial weathering.

Rettger (18) in his Alabama investigations and Bramlette (19) in his Arkansas work show definite evidence that bauxite and associated substances lie immediately at the top of the Midway subjacent to the Wilcox, and that the beds are the product of prolonged sub-aerial lixiviation of aluminous clays (also syenite in Arkansas). These facts appear to correlate the south Alabama and the Arkansas deposits with the Betheden formation of Mississippi.

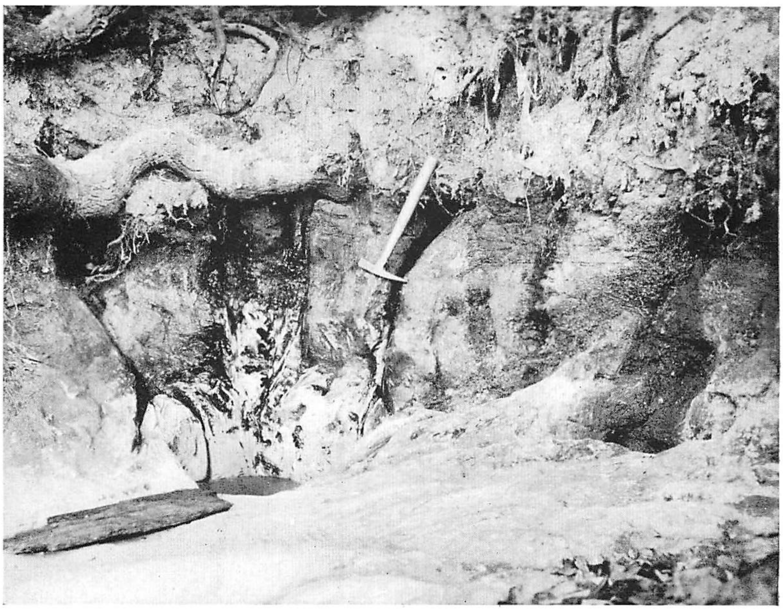


Figure 5.—Type exposure of the Betheden formation at Livingston Spring, 50 yards south of the highway at Betheden (SW. ¼, SE. ¼, Sec. 23, T.16 N., R.13 E.), showing weathered lignite above pick point and sandy bauxitic clay below.---October 27, 1937.

The Betheden is considered a definite formation because:

1. The beds are a distinct lithologic unit;
2. The residuum represents a time interval probably equivalent to the period required for the accumulation of one formation or perhaps several formations of sedimentary materials;
3. The materials are much thicker in the aggregate and far more highly weathered than other underclays;
4. The unit can be traced hundreds of miles;
5. Genetically, it is altogether different from overlying and underlying beds.

Bauxitic and kaolinitic materials are one of the accepted evidences of unconformity. A recent bulletin of the Mississippi Geological Survey (20) called attention to a Lower Cretaceous residuum (Little Bear) of lateritized clays of great thickness and extent in Tishomingo County, lying nonconformably below the basal beds (Tuscaloosa) of the Upper Cretaceous. The Betheden residuum, if properly correlated with the Arkansas deposits, is thought to have been forming over a period of perhaps 1,000,000 years or longer (19). Its contact with the overlying Wilcox sediments is, therefore, a prominent erosional unconformity marked in the complete section by the top of its lignite.

Midway-Wilcox Contact

The unconformable contact of the Midway and Wilcox series represents a cessation of sedimentation of probably 1,000,000 years or longer (19) during which the underlying marine mud and silt were being compacted, lixiviated, and lateritized sub-aerially, and subjected to the ordinary processes of erosion. The topography was such as to allow leaching to a maximum depth of 25.0 feet, more or less, a topography comparable to the Flatwoods topography of the present day. The relief on the Betheden surface is nowhere in Mississippi very great, but it is, in some places, confusing to one expecting regularity of dip as of sedimentary beds. The lignite on the surface of the Betheden seemingly did not accumulate at all points, especially on the old topographic "highs."

After the Betheden was formed the entire Mississippi area was rejuvenated, inaugurating Wilcox deposition. The bauxitic and kaolinitic substances were eroded and redeposited as thin unimportant lenses in the base of the Fearn Springs, or, more rarely, in the base of the Ackerman.

The following section shows the Midway-Wilcox unconformity where the Betheden is absent:

Section on the Chester Coleman estate (W. ½, NE. ¼, Sec. 3, T.15 N., R.13 E.)

	Feet	Feet
Fearn Springs formation		45
Soil, yellowish residual	10	
Siltstone, thin ferruginous at unconformity; medium-to fine-grained argillaceous sand, cross-bedded, containing a few clay balls and streaks of clay; thin beds of laminated silty		

	Feet	Feet
clay in lower part; upper half of interval dominantly fine-grained sandy finely laminated sparingly micaceous clay containing comminuted lignitic material; argillaceous fine-grained sand lenses subordinate	35	
Disconformity		
Porters Creek formation		56
Clay, slightly laminated sandy, micaceous conchoidal somewhat sulphurous, ferriferous dark carbonaceous, grading upward into a phase more evidently laminated containing concretions of impure (and oxidized) siderite; a few short fine-grained micaceous, sand lenses near the top of the formation; clay much jointed by southeast trending planes, lined with limonitic material	34	
Covered-to level of Mill Creek	22	

Records of test holes 101, 119, 153, and others show the contact at other localities.

Figure 4 shows the contact where the Betheden formation was eroded and the Ackerman deposited.

WILCOX SERIES

General

The Wilcox series of Winston County is composed of successions of sand, silt, clay, and lignite, of beds seemingly lenticular or interdigitate. Lowe (11) recognized four distinct divisions of the Wilcox (Fig. 6): (1) the Ackerman, predominantly clay; (2) the Holly Springs, predominantly sand; (3) the Bashi (in Lauderdale County), predominantly marine "marl"; and (4) the Hatchetigbee (Lauderdale County) or Grenada, predominantly lignitic clay.

Grim recognized certain additional minor divisions as shown in Fig. 6. His detailed petrographic studies point to the conclusion that the Wilcox sediments, except in the area of Lauderdale County, are successions of deltaic, fluvial, eolian, lagoonal, and other continental deposits.

Series	Mississippi: Crider 1906	Mississippi: Lowe 1933	Mississippi: Grim 1936	Mississippi: Mellen 1938 Winston County	Alabama: Cooke 1933
Claiborne	Tallahatta	Tallahatta Meridian sand (at base)	Tallahatta Winona Basic Meridian	Tallahatta Winona (?) Basic Meridian	(not correlated)
Wilcox	Wilcox	Grenada (west) Hatchetigbee (east)	Grenada	Hatchetigbee	Hatchetigbee
		Bashi (Lauderdale County)	Bashi (Lauderdale County)	Holly Springs	Bashi
		Holly Springs	Holly Springs		Tuscahoma
		Ackerman	Ackerman	Ackerman (restricted)	Nanafalia (restricted)
					(overlapped)
				Fearn Springs	Ackerman
Midway	Porters Creek	Porters Creek	Porters Creek	Betheden	Naheola
				Porters Creek	Porters Creek
	Clayton	Clayton	Clayton	Clayton (not exposed)	Clayton

Figure 6.—Correlation table of lower Eocene beds of Mississippi and Alabama.

The formations are here being separated on the basis of certain persistent unconformities in the Wilcox between fine- to coarse-grained arkosic (?), micaceous grit-bearing bowlder-bearing sands, and fine-grained argillaceous sands or silts or lignitic clays.

In recent years stratigraphy has been given the cyclical hypothesis (cyclothem: *cyclos*, cycle, and *thema*, a deposit), an idea developed for the Pennsylvanian coal measures of the Interior and Northern Appalachian fields by Wanless and Weller (27). A normal cyclothem is composed of the following:

Marine Sediments

8. Shale with "ironstone" nodules and bands
7. Limestone with marine fossils
6. Black sheety shale with large concretions

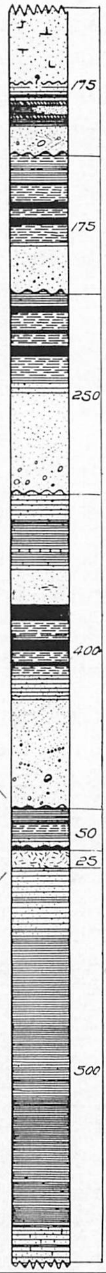
Continental deposits

5. Coal
4. Underclay
3. Limestone without marine fossils
2. Sandy shale
1. Sandstone, unconformable on lower beds

While engaged in work for the Tennessee Valley Authority in northeastern Mississippi, F. E. Vestal and the writer found a very interesting problem in the rather wide distribution of pebbles, cobbles, and bowlders of quartz and quartzite, associated generally with a medium-grained to very coarse-grained quartz sand. The study of this problem has been continued until a partial solution has been found.

On the application of the cyclical hypothesis to the Wilcox sediments of Mississippi, it is seen, that, although the marine facies are absent north of the Lauderdale County area, the hypothesis nevertheless helps with astonishing success in the division of the Wilcox into formations or cyclothems.

The Winston County work has shown distinctive units of coarse sand, dis-conformably overlying argillaceous or silty beds (See Figs. 7, 14). It has shown, also, sequences in the Eocene beds of Mississippi correlative with those of the cyclical hypothesis.



Series	Formation-Member	Thickness (feet)	Description
Claiborne	Tallahatta Winona (?) Basic Meridian	175	Ferruginous sandstone; light-colored siltstone; siliceous sedimentary clays; masonry sand
Disconformity			
Wilcox	Hatchetigbee	175	Lignite; siliceous underclays; lignitic clays; ferruginous sandstone; masonry sand
	Disconformity		
	Holly Springs	250	Lignite; siliceous underclays; lignitic clays; ferruginous sandstone; masonry sand
	Disconformity		
	Ackerman	400	Lignite; siliceous underclays; lignitic clays; ferruginous sandstone; masonry sand
	Disconformity		
	Fearn Springs	50	Ball clay; stoneware clay; lignite
Disconformity			
Midway	Betheden	25	Kaolinitic clay; bauxitic clay; lignite
	Conformity		
	Porters Creek	500	Clay, marine carbonaceous montmorillonitic; sandy and micaceous toward top; sandy calcareous toward base

Figure 7.—Generalized section of rocks of Winston County showing thickness in feet.

In this report four divisions of the Wilcox are recognized: (1) Fearn Springs, (2) Ackerman, (3) Holly Springs, and (4) Hatchetigbee. The Fearn Springs is a newly recognized unit, lying super-jacent to the Betheden formation of Midway age and sub-jacent to the Ackerman formation. The Ackerman is restricted to the beds super-jacent to the Fearn Springs formation and sub-jacent to the Holly Springs formation and includes not only the clays and lignites as exposed in the type locality but a persistent basal sand member. The Holly Springs is restricted in Winston County to beds super-jacent to the Ackerman formation and sub-jacent to the Hatchetigbee formation which has been thought heretofore to be missing n Winston County. "Hatchetigbee" is the name chosen for the beds super-jacent to the Holly Springs and sub-jacent to the basal Meridian sand member of the Tallahatta formation, since it has priority over the name Grenada.

The Tallahatta formation, retained in the Claiborne, appears to be a peculiarly modified cyclothem. The unconformity at the base, however, presents the same features as the Wilcox unconformities, and the basal sand (Meridian member) is in many respects similar to the basal sands of the Wilcox cyclothems.

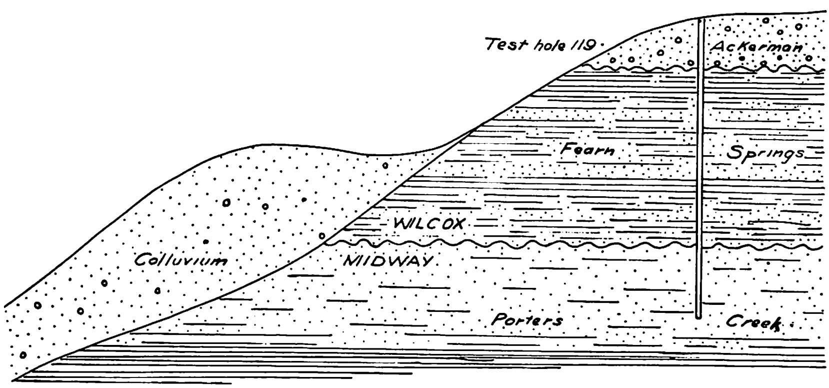


Figure 8.—Cross-section of Fearn Springs formation at type locality (NE. ¼, Sec. 3, T.13 N., R.14 E.), showing stratigraphic relations.

Fearn Springs Formation

In the complete section, the Fearn Springs formation (Fig. 9) lies disconformably on the lignite of the Betheden formation (Fig. 8, 9) and is disconformably overlain (Figs. 8, 10) by the grit-bearing arkosic (?) sand of the Ackerman formation. Because of these stratigraphic relations, persistent throughout the state, the beds included in the unit are regarded as a new formation whose type locality is at Fearn Springs (SE. 1/4, NE. 1/4, Sec. 3, T.13 N., R.14 E.), Winston County. The stratigraphic relations and lithologic character are shown in Figs. 6 to 10, and in the record of test hole 119.

Figure 9.—Contact of the light-colored refractory Betheden bauxitic clay below and the plastic Fearn Springs clay above on the J. J. Moody and T. P. Sullivan properties (NW. 1/4, SE. 1/4, and NE. 1/4, SW. 1/4, Sec. 33, T.14 N., R.14 E.). At the crest of the road test hole 101 showed 25.1 feet of Fearn Springs Clay.---October 22, 1938.

The Fearn Springs formation is probably the most important formation, economically, in Winston County. Throughout the state, it contains ball-type clays, good stone-ware clays, silty clays, silt, sand, lignite, and siderite. The silt, sand, lignite and siderite are of no importance in Winston County; in the northern part of the state siderite is highly developed in Tippah and Benton counties, in the latter of which it is mined for pigment by the Geo. S. Mepham Company. The stoneware clays are exposed in places in Tippah, Benton, Union, Pontotoc, Winston, and Lauderdale counties, and are probably present in the intervening ones. Little is known yet of the distribution of the ball clays of the formation. The present investigations show that they are important in Winston County. The sand, present chiefly in the base, is normally very fine-grained, less micaceous than the older Porters Creek, in places cross-bedded, and in places containing reworked or redeveloped pisolites (pseudo-pisolites); locally, however, the basal member seemingly contains coarse sand and small quartz pebbles.

The thickness of the Fearn Springs formation ranges from a feather edge to more than 50 feet.

Figure 10.—Fearn Springs formation at the type exposure (NE. 1/4, Sec. 3, T.13 N., R.14 E.) 0.25 mile west of Fearn Springs; the paper marks the unconformity between the Fearn Springs below and the Ackerman above.---October 22, 1938.

It is probably a significant fact that in the lower parts of two great sedimentary series, both overlying partly preserved residual beds, there are extensive deposits of commercially valuable ball and stoneware clays. The reference includes the other clay deposits in the Tuscaloosa formation which is the lowest of the Upper Cretaceous series and super-jacent to the Little Bear residuum (20). These clays are utilized in a small way by numerous stoneware "jug shops" in southeastern Itawamba and northeastern Monroe counties and in adjacent Alabama. The Fearn

Springs formation likewise has supported stoneware "jug shops" along its belt of outcrop. Only two are now in operation, the Stewart Pottery in Winston County and the Lauderdale (Lavender) Pottery in Lauderdale County. The significance of these stratigraphic relations points to an ultimate origin of these clays in the development of the residua. It is likely that they are sedimentary after being reworked and reassorted from pre-existing surface clays. The purer clays of the Fearn Springs show distinctly that their fineness of grain is due not only to sorting but to leaching by roots and organic solutions immediately subsequent to deposition. The hypothesis seems to fit the actual conditions in both the Cretaceous and Eocene strata. It would account for the fact that clays higher in the two series and farther seaward do not present the same characteristics, since the ultimate sources, well-developed land surfaces, were not so available as prior to beginning of deep and continuous subsidence.

The Fearn Springs formation, lying as it does beneath a heavy cover of sand, is both difficult to prospect and hard to interpret. In wet seasons, when its plasticity is greatest, the over-lying sands, because of their permeability and thickness, increase in weight thousands of tons an acre. On hill slopes, therefore, a pressure differential is developed which results in flow of the clay strata, in landslip, and in colluvial creep or over-ride of the sand bed; phenomena easily mis-interpreted. It is difficult, therefore, to secure absolutely unweathered samples of the clay. Petrographic studies of fresh samples should be a valuable aid in determining the ultimate source of the Fearn Springs clays and the exact mode of their accumulation. This knowledge would be helpful in future prospecting.

As shown in the correlation table (Fig. 6), the Fearn Springs is possibly equivalent to the Ackerman formation as limited in Alabama by Cooke (25), or to the old "Coal Bluff series" of Langdon (26). At the time of Cooke's correlation, the Ackerman was defined as all the Wilcox below the Holly Springs formation. The Coal Bluff beds may possibly, therefore, be Fearn Springs in age. On May 25, V. M. Foster and the writer found what appeared to be glauconitic marine clay associated with the other clays and lignite of the Fearn Springs in northern Lauderdale County where the basal Ackerman grit overlies the Fearn Springs as farther north.

The following test hole records give descriptions of the Fearn Springs at definite localities: 17, 27, 58, 61, 101, 103, 106, 119, 147, 150, 153, 154.

On the southwest side of Bevill Hill (NE. ¼, Sec. 24, T.16 N., R.13 E.; NW. ¼, Sec. 19, T.16 N., R.14 E.) the full thickness of the Fearn Springs is 25.0 feet shown in the following section:

	Feet	Feet
Ackerman formation		16.5
Sand, medium-grained to coarse-grained angular coarsely micaceous, ferruginous (red) highly weathered and mottled by old root channels	16.5	
Disconformity (as at Webster)		
Fearn Springs formation		25.0
Silty material, probably originally same as below but highly ferruginous and structureless because of weathering	4.8	
Clay, evenly bedded micaceous very silty laminated	12.0	
Silty material, micaceous, ferruginous (limonitic)	0.2	
Sand, cross-bedded and lenticular fine grained to medium-grained, and large flakes of muscovite; thin and irregular lenses of stoneware clay and reworked bauxite	8.0	
Disconformity (marked by thin ironstone)	0.1	0.1
Porters Creek formation		30.0
Clay, top part ocherous, kaolinitic yellow-gray mottled; limonite plates along laminae; lower part dark-gray silty; micaceous laminated closely jointed	30.0	

A comparison of the description of the Fearn Springs as given in the section above, in the Chester Coleman section, and in the test hole records shows a great diversity in quality.

Ackerman formation

The name Ackerman was applied in 1913 by Lowe (29) to the 55 feet of lignite, silt, and clay underlying 30 feet of sand (Holly Springs) exposed in Blantons Gap on the Illinois Central Railroad 1¼ miles northeast of Ackerman, Choctaw County. The name has become fixed in the nomenclature, and has been applied to Alabama strata by Cooke (25). In the present report, however, it is found necessary to restrict the Ackerman formation to those beds lying above the Fearn Springs formation and below the Holly Springs formation; in other words, the Midway-Wilcox "transitional beds" or "basal clays" of Lowe and other writers are removed from the Ackerman formation for the stratigraphic reasons cited elsewhere in this report.

In Winston County the formation varies somewhat in thickness, but its main development is within the range of 300 to 400 feet. The early Ackerman or pre-Ackerman stream currents provided an uneven base for deposition, and the post-Ackerman-pre-Holly Springs or early Holly Springs stream currents seemingly channeled the top of the Ackerman formation appreciably. As typically developed, the Ackerman formation, and the other Wilcox cyclothems, can be divided arbitrarily into the following:

4. Clay, laminated silty, containing comminuted plant remains and leaf impressions; and massive or laminated silt;
3. Underclay, and silty lignitic clay, regularly deposited successions of lignite;
2. Silt, or silty clay, evenly bedded, laminated, containing comminuted plant fragments;
1. Basal sand, highly cross-bedded containing sporadic accumulations of grit and pebbles and sporadic cobbles and bowlders.

This grouping of the strata, roughly in accord with the sequence expressed by the cyclical hypothesis, is applicable to the following section, which is probably one of the most nearly complete and most instructive Ackerman formation sections in the state.

Section of the Ackerman formation between Poplar Flat Church and Sulphur Springs Creek (Sec. 10, T.15 N., R.12 E.)

	Feet	Feet
Upper Ackerman (lignitic and silty beds)		100.1
Soil and subsoil (brown sandy loam) to top of hill	8.0	
Siltstone, ferruginous	0.1	
Clay, lignitic very silty uniform; containing good leaf impressions (this bed sampled in Sec. 15 in test hole 57)	27.2	
Lignite, smut, and lignitic clay	1.8	
Clay, gray plastic fine-grained gypsiferous (sampled in test hole 75, etc.)	8.8	
Clay, very silty plastic	5.3	

	Feet	Feet
Lignite, soft, weathered	0.5	
Clay, brownish-gray plastic somewhat lignitic	3.4	
Lignite, soft, weathered	0.6	
Clay, brownish-gray plastic somewhat lignitic	2.7	
Lignite, impure	0.5	
Clay, silty micaceous, gypsiferous	2.7	
Clay, very silty micaceous laminated; containing lenses and thin beds of sand at the base; more regularly bedded above; contains comminuted plant matter throughout	38.5	
Lower Ackerman (basal sand member)		27.0
Sand, cross-bedded, and thin beds of clay; much ironstone, chiefly as large pipe concretions	4.5	
Sand, find-grained to medium-grained micaceous arkosic (?) highly cross-bedded (three sets); contains thin streaks of clay	11.0	
Covered, to level of creek	11.5	

The Ackerman formation section at Blantons Gap correlates closely with the above section, except that it has a much less thickness of the upper silty beds. As the Holly Springs formation is not exposed in the Poplar Flat section nor in the immediate vicinity, the proximity of the Holly Springs basal sand to the uppermost lignite seam is definite evidence of the unconformity between the two formations.

Section of the Ackerman formation at Blantons Gap on the Illinois Central Railroad northeast of Ackerman, Choctaw County

	Feet	Feet
Holly Springs formation (basal sand member)		25.0
Sand, fine-grained to coarse-grained argillaceous cross-bedded; containing a few small quartz pea-gravel pebbles; sporadic concentrations of clay pebbles and boulders throughout	25.0	
Disconformity (erosional; marked by thin ferruginous sheets)		
Ackerman formation (lignitic and silty members)		59.0
Clay, very silty laminated lignitic; weathers to chocolate color; contains sand lenses; bears good leaf impressions (same stratum as at Poplar Flat Church, etc.)	6.5	

	Feet	Feet
Underclay, massive; root impressions; slightly silty just below top; very fine-grained below	8.3	
Lignite, weathered	0.9	
Underclay, massive; root impressions; slightly silty	8.0	
Sand, fine-grained argillaceous, slightly lignitic unevenly bedded; a parting of clay near the middle	2.5	
Clay, slightly silty laminated; sporadic siderite concretions in lower part and a few pyrite nodules throughout	6.3	
Lignite, smut with thick clay parting	1.2	
Underclay, silty; lower part laminated; numerous fine root impressions especially near the top	3.6	
Silt and sand, fine-grained argillaceous; ripple marks; numerous bands of ferruginous siltstone, a prominent one at the top	5.9	
Clay, indistinctly laminated silty conchoidal lignitic	7.1	
Underclay, fine root impressions; ferruginous at base	1.4	
Sand, fine-grained argillaceous laminated containing thin iron-stone sheets	1.8	
Clay, silty laminated containing siderite concretions (0.2 feet thick) 2 feet from bottom; some pyrite nodules and a few fossil leaves	5.5	
Bottom of ravine		

The basal member of the Ackerman formation is a grit-bearing, pebble-bearing, cobble-bearing and bowlder-bearing quartz sand whose maximum thickness is 125 feet or more. This sand member has not been recognized previous to this survey. The latest geologic map of the state (10) shows that the Holly Springs formation overlaps the Ackerman formation and a part of the Porters Creek formation in the northern part of Mississippi. This is probably a misinterpretation of the stratigraphy, due in part to the more arenaceous character of the northern Wilcox formations. In Winston County the sand has been referred to the Naheola formation (11). Definite evidence of its stratigraphic position is shown in the Poplar Flat Church section, Figs. 10 and 11, in the log of the deep well at Louisville (10), and in test hole records 3, 18, 20, 23, 57, 70, 83, 84, 122, 167, etc. Moreover, the writer and F. E. Vestal traced it a hundred miles through the state by means of the sporadic stream-worn cobbles and bowlders it contains.

Figure 11.—Contact of the basal sand below and the lower silt beds above of the Ackerman formation on the south bluff of Sulphur Springs Creek (SW. ¼, NW. ¼, Sec. 10, T.15 N., R.12 E.).---October 22, 1938.

The presence of these cobbles and bowlders makes the unit one of the most remarkable geologic features not only of Mississippi, but of the entire North American continent. In 1937, Vestal and the writer collected one quartzite bowlder weighing 96 pounds and saw another even larger. Numerous smaller bowlders and cobbles of quartzite and quartz were found widely distributed over the sand area, but nowhere were they abundant. Chert is extremely rare. Fig. 12 shows a collection of these stones made in Winston County.

By far the largest stone seen by the writer was found by him and W. C. Morse, on June 16 in the pasture of J. J. Moody (NE. ¼, NE. ¼, Sec. 33, T.14 N., R.14 E.), a quartzitic-grit boulder weighing 905 pounds!

This bowlder has a mortar ground into its upper side by the Indians. The lower part, which was buried in the ground, shows the unmistakable smoothness of stream-wear. The bowlder has been taken to the University of Mississippi where it is displayed at the Mississippi Geological Survey.

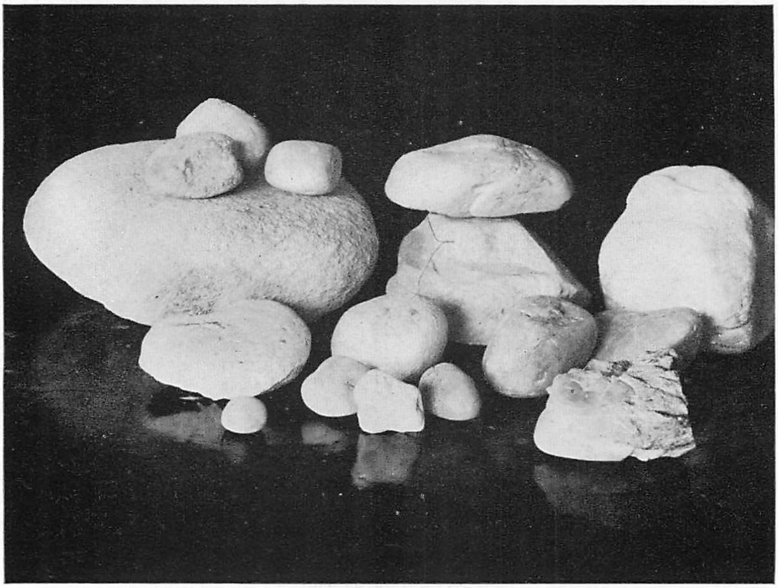


Figure 12.—Pebbles and bowlders from the basal sand of the Ackerman formation, eastern Winston County; the largest weighs 23.1 pounds.

The source of these materials is evident. The larger stones are quartzitic grit very similar to the Pottsville (Millstone) grit of the Sand and Cumberland mountain areas. Some of the smaller ones are vein quartz and metamorphic quartzite, rocks which have been derived from the crystalline area of the southern Appalachian Mountains. The closest exposed materials of these varieties are almost 100 miles to the east and northeast, but physiographic and stratigraphic evidences point to a more remote source, 200 miles or more.

Because a few cobbles appeared to be faceted their distribution was thought to be due, possibly, to glacial or aqueo-glacial agencies. Atwood (28) described the Ridgway till of the Lower Eocene of Colorado and suggested the possibility of more extensive Eocene glaciation in North America. The Ackerman sand is water-laid material and examination of hundreds of pebbles, cobbles, and bowlders has not yet revealed a single mark of striation.

Perhaps the most reasonable explanation would be the postulation of a great Appalachian up-lift, increasing the stream gradient and the velocity of the run-off, and of torrential seasonal rains, producing diluvial conditions in the piedmont area. Even under such conditions the larger stones would have had to have been floated down in the roots of gigantic trees. While there is physical basis for these postulations, it is difficult to conceive of the transportation of these stones even under most favorable conditions of this sort. The problem is one meriting much additional study.

The only lacustrine (?) limestone observed by the writer in Mississippi was reported by B. Henson, a prominent citizen of Winston County. It crops out on the land of L. F. McMillin (SE. ¼, SE. ¼, Sec. 1, T.15 N., R.11 E.), and, according to Henson, on properties to the north. It is a hard dense earthy rock ten to twelve inches thick. The top part of two or three inches is replaced (?) by siderite, altered on exposure to limonite. These carbonate rocks lie between strata of greenish silty clay. The stratigraphic position of this limestone is between 50 and 100 feet below the top of the Ackerman formation. Thompson (21) could find no foraminifera in the clay below, in the clay above, nor in the limestone itself.

By correlating the records of test holes 3, 20, and 70, all on the John Lowery (U. S. Resettlement Administration) property, it is determined that there is an aggregate thickness of 98.6 feet of the mid-Ackerman which was carefully examined for lignite and clay. These beds contain four seams, aggregating 13.7 feet of lignite (13.9 per cent), the upper two of which are of workable thicknesses.

The Ackerman formation seems to vary greatly over short distances, but a fairly close correlation of the lignite beds, despite the fact that they seem to be locally absent, and of the more general units, is possible over long distances within Winston County and in adjoining counties.

Holly Springs formation

The Holly Springs consists of 200 to 300 feet of sediments in Winston County, of similar characters and sequence to those in the Ackerman formation. The basal sand, however, is rarely grit-bearing and generally exhibits better sorting than the thicker basal Ackerman sand. Lignite is common in the Holly Springs formation and underclays are present. No detailed work has been done on these beds of Winston County, and, because they are commonly less accessible to transportation than the Ackerman beds, the underclays and lignite were not investigated by the present survey.

The basal sand of the Holly Springs formation is well exposed in the great Watson sand pit 2.5 miles southwest of Louisville (NW. ¼, Sec. 5, T.14 N., R.12 E.) (Figure 13). It caps the hills at Noxapater; it also caps the hills along the Noxubee-Pearl divide in northern Winston County.

Figure 13.—Basal sand of the Holly Springs formation in the Watson pit (NW. ¼, Sec. 5, T.14 N., R.12 E.).---October 22, 1938.

The top of the Holly Springs formation, a somewhat weathered highly plastic lignitic underclay, is exposed in the public road at Ford School House (SW. ¼, NE. ¼, Sec. 5, T.14 N., R.11 E.) about 8.0 miles west of Louisville, where it is non-conformably overlain by the basal sands of the Hatchetigbee formation. R. E. Jernigan reported that a well drilled by him at this location penetrated the thickest lignite of which he had knowledge, 18.0 to 20.0 feet, part of which may, however, have been lignitic clay. The survey was denied permission to bore at this location, so there is no verification of Jernigan's interesting statement.

A fairly complete section of the Holly Springs formation was obtained south of the Highway 15 underpass about 4.5 miles southwest of Noxapater.

Section of Holly Springs and Hatchetigbee formations, beginning at the underpass of Highway 15 and Gulf, Mobile, & Northern Railroad (SE. ¼, Sec. 31, T.13 N., R.12 E.), Winston County, and running for a half mile up the hill and into Neshoba County.

	Feet	Feet
Hatchetigbee formation (basal sand member)		27.5
Sand, very micaceous, fine-grained to medium-grained cross-bedded very ferruginous; many pipe concretions and ironstone bands	27.5	
Disconformity (covered by colluvium on north side of hill)		
Holly Springs formation (upper part)		72.0
Interval mostly covered; silty clay as below; possible some lignite and underclay	30.0	
Interval partly covered; most or all silty laminated clay, numerous small lenses of fine-grained sand	33.0	
Clay, bentonitic (?) silty laminated	5.5	
Clay, silty; contains leaf fossils, blades of a monocotyledon being very abundant	3.4	
Siltstone, ferruginous	0.1	
Holly Springs formation (basal sand member)		16.5
Sand, very fine-grained micaceous, arkosic (?) cross-bedded; clay pebbles and laminae throughout; contains dark grains; silty and argillaceous toward top	16.5	

Hatchetigbee Formation

The Hatchetigbee formation probably consists of 150 to 200 feet of sediments in Winston County, of similar character and sequence as in the underlying Ackerman and Holly Springs formations. It contains basal sands and lignite, underclay, silt, and silty clay. It overlies the Holly Springs formation disconformably (Ford School House) and is overlain disconformably by the Meridian sand member of the Tallahatta formation (SE. ¼, SE. ¼, Sec. 30, T.14 N., R.10 E., etc.). Eighteen and a half miles west of Louisville near Rural Hill (NW. ¼, SE. ¼, Sec. 18, T.14 N., R.10 E.) there is a 15-foot outcrop of fairly dense silty lignitic leaf-bearing clay (Test hole 173) which is probably equivalent in age to the leaf-bearing beds at Grenada.

Because of the remoteness of the Hatchetigbee formation from transportation only one sample was taken for testing.

The western part of Winston County is largely cut-over land, mostly state-owned or corporation-owned. Much of it is sparsely settled, the roads are poor, and the available maps entirely inadequate. The mapping of the geologic units is, therefore, very generalized, and the boundaries of the Hatchetigbee and underlying and overlying formations have not been accurately determined except at a few points.

CLAIBORNE SERIES

TALLAHATTA FORMATION

The Tallahatta formation of Winston County is 175 to 200 feet thick. The three members recognized by Grim (16) are present: the Meridian sand, 45 to 60 feet; the Basic siltstone, 45 to 60 feet; and the Winona sand, a maximum of 90 feet.

The Meridian sand member is very similar to the basal sands of the Wilcox formations, cross-bedded, micaceous, arkosic (?), argillaceous, and grit-bearing and bowlder-bearing. A schistose quartzite cobble weighing seven pounds four ounces was found in the base of the Meridian sand where the following section (Fig. 14) was measured.

Section of Hatchetigbee and Tallahatta formations, beginning in the SE. ¼, SE. ¼, Sec. 30, T.14 N., R.10 E. and running to the Winston-Attala line

	Feet	Feet
Tallahatta formation, Basic member		15
Claystone and siltstone, regularly bedded, containing glauconite in some beds and none in others; more or less bentonitic and patchy from animal borings, to top of hill; contact with underlying beds sharp but conformable	15	
Tallahatta formation, Meridian member		61
Sand, light-colored non-glauconitic cross-bedded containing lenses and patches (as of borings) of silty bentonitic clay	6	
Sand, more regularly bedded than below; clay seams	40	

	Feet	Feet
Sand, coarse cross-bedded; clay, quartz, and quartzite grit, pebbles, and cobbles (rare)....	15	
Disconformity (very irregular and sharp)		
Hatchetigbee formation		5
Clay, laminated, and sand, fine-grained evenly bedded, weathering to pinkish	5	
(Bottom of ditch)		

The hill on which Plattsburg is located, the prominent ridge in the SE. ¼, Sec. 12, T.13 N., R.10 E., and the ridge at Rural Hill are conspicuous localities of the Meridian member.

Figure 14.—Unconformity between the Hatchetigbee formation below and the Meridian member of the Tallahatta formation (SE. ¼, Sec. 30, T.14 N., R.10 E.).---April, 1938.

Mars Hill (Secs. 34 and 35, T.13 N., R.10 E.) shows almost a complete section of the Tallahatta. At the base of the hill near the branch, lignitic clay (Hatchetigbee) is exposed on the roadside. A test hole drilled near the foot of the Basic member exposure higher on the hill did not strike this clay in 40.8 feet. Combining the test hole record with the measured exposures above gives a composite section as follows.

Section of the Tallahatta formation at Mars Hill, beginning at test hole near base of siltstone in S. ½, SE. ¼, NW. ¼, Sec. 35, T.13 N., R.10 E., and running to crest of ridge at Mars Hill Church (SE. ¼, NE. ¼, Sec. 34, T.13 N., R.10 E.)

	Feet	Feet
Winona member		88.0
Sand, fine-grained to medium-grained very micaceous, very ferruginous; some lenses of silty clay near middle; interval partly covered; top of hill	88.0	
Disconformity (?) marked by ferruginous siltstone band		
Basic and Meridian members		83.7
Covered interval, mostly; silty clay below; micaceous silt above; non-glauconitic	20.0	
Siltstone, claystone, glauconitic in places; mottled by fillings of animal borings; beds up to 2 feet alternating with silty clay as below	25.0	
Clay, very silty micaceous; bentonitic and lignitic; a few thin lenses of claystone in upper part	10.6	
Sand, fine-grained argillaceous, micaceous, containing black grains; clay pebbles in lower part; yellow, brown, and gray	21.0	
Clay, gray plastic	0.6	
Sand, light-cream to yellow fine-grained micaceous	6.5	
(Bottom of test hole)		

The suggestion of an unconformity between the Basic and Winona members is strong, and the contact between the two should be examined elsewhere in the state to see if there is a widespread unconformity.*

The basic member in Winston County is divided, at least locally, by a sand parting as shown in the following section.

*Since the manuscript of this report was prepared, outcrops in other counties have been examined. These outcrops show that the Winona overlies the Basic disconformably, and that the Winona is the conformable basal member of the Lisbon formation.—June 17, 1939.

Section of the Basic member of the Tallahatta formation in the NE. 1/4, SW. 1/4, Sec. 32, T.13 N., R.10 E.

	Feet	Feet
Basic member		61.8
Covered	5.0	
Clay, silt, siltstone, sand, and sandstone, alternating beds; non-glauconitic, bentonitic; numerous sporadic borings and fillings near bottom; some quartzite nodules	13.0	
Sand, light-colored fine-grained; a little mica and dark grains; cross-bedded at top; contains clay stringers	11.0	
Covered	22.0	
Clay, silty bentonitic	2.5	
Silt and siltstone, alternating irregular layers	1.5	
Silt, firm but soft, relatively uniform lightweight; a little glauconite	1.0	
Siltstone, hard; material same as below	0.1	
Silt, bored bentonitic, glauconitic, sandy soft	0.7	
Covered, to flood plain level	5.0	

Figure 15.—Deep-red fossiliferous sand of the Winona member (?) of the Tallahatta formation in Sec. 19, T.13 N., R.10 E.---May, 1938.

Some of the higher hills in the southwestern township of Winston County have irregular masses of fossiliferous ferruginous sandstone (Fig. 15), characteristic of the Winona member. The top of the Winona member is nowhere exposed in the county. At "Four Corners", the common point of the four counties, the bedrock is the Basic member, the hill being too low for the Winona member.

QUATERNARY DEPOSITS

Contrary to the expectations of the writer when he came to Winston County, there are no high stream terraces in the region. Detailed work has shown that the thick hilltop sands are basal sands of Wilcox and Claiborne formations, and that they extend beneath the silty, argillaceous, and lignitic beds for which the formations are noted (Fig. 11).

The streams of the Porters Creek clay (Flatwoods) belt in eastern Winston County have, because of the favorable conditions, formed extensive terraces of the sandy and silty material derived from the hilly Wilcox area to the west. The broad flats and the yellowish or brownish color of the sandy soils make these terraces unmistakable, even where the sharp contact with the underlying Porters Creek clay is not exposed. (Fig. 1).

On lower Tallahaga Creek (T.13 N., R.13 E.), there seem to be several distinct stream terraces. The level expanse of the lands around Claytown and on both sides of the Tallahaga Creek is evidence, confirmed by the coarser clastic materials lying unconformably at various levels above the argillaceous Ackerman beds.

The stream terraces in all cases are connected with the development of present-day drainage features.

MINERAL RESOURCES

IRON

Minerals of two metals, iron and aluminum, are found in Winston County. The iron is principally in the form of siderite as concretions, varying greatly in size, shape, and purity. The most ferriferous beds are in the top part of the Porters Creek formation where the siderite is extremely silty and micaceous, reflecting the general character of these beds. The iron ore of the Porters Creek formation varies in thickness from an inch or less to a foot or more, and in some places is present as more or less continuous beds. In the Wilcox beds of Winston County the siderite is generally much purer than that of the Porters Creek formation, the quality appearing to vary directly with the purity of the associated clay. The siderite seams in the Ackerman, Holly Springs, and Hatchetigbee formations appear in many cases to have a fixed position in relation to the seams of lignite, lying near the base of the underclays. In general the siderite nodules or concretions of the Wilcox in Winston County are thin and disconnected. The siderite of both the Midway and Wilcox weathers on exposure to limonite which is nowhere present in large quantity.

The present survey has disclosed no beds of iron ore that combine both the quality and quantity to justify any mining operation either for pig iron or paint pigment.

ALUMINUM

The principal commercial ore of aluminum is bauxite ($Al_2O_3.2H_2O$). All the bauxite in Winston County is in the Betheden formation which is residual from the Porters Creek clay. The bauxite varies in quality laterally and vertically, grading into ferruginous phases on the one hand, and into kaolinitic phases on the other. There is little bauxite in Winston County of high enough quality to prove interesting. The best analysis (8) available of bauxite in Winston County is of the sample taken from the Sullivan property (Sec. 27, T.14 N., R.14 E.). This bauxite is from a residual outlier capping a small hill. There are no other exposures of bauxite close by, and other bauxite, if present, is covered by sand colluvium. The analysis is:

Aluminum oxide (Al_2O_3)	55.84
Ferric oxide (Fe_2O_3)	4.56
Silicon dioxide (SiO_2)	15.04
Titanium dioxide (TiO_2)	1.80
Loss on ignition	21.92
Non-volatile with HF	1.62
Moisture	0.30
	101.08

It is probable that because of the low quality of the bauxitic material there will be no commercial developments of the bauxite for aluminum manufacture. For this reason the bauxite materials will be discussed under non-metallic minerals.

OIL AND GAS

Three deep wells have been drilled for oil and gas in Winston County:

1. Mississippi Drilling Company, Scarbrough No. 1 started October 2, 1930; NW. ¼, NW. ¼, Sec. 15, T.13 N., R.14 E.; depth 2537 feet; show of gas in Selma; show of oil in Tuscaloosa;

2. Peckham-Camp, Watkins No. 1 started October 30, 1933; Sec. 12, T. 13 N., R.11 E., depth 2544 feet; dry hole;

3. Jack R. Vale, Moody No. 1 started August 24, 1934; NW. ¼, SW. ¼, Sec. 3, T.13 N., R.14 E.; depth 2740 feet; show of gas at top of Selma; show of oil and gas in Eutaw.

On January 30, 1933, R. N. Kinnaird submitted to the Adams Edgar Lumber Company of Morton, Mississippi, an assemblage of maps and reports relative to several "structures" on or adjacent to their properties.

According to Kinnaird, the "Fearn Springs structure," one of those covered by his compendium, was discovered by Julian in 1929. Julian's discovery was made from stream pattern and confirmed by him with "Several observations of magnetic intensity." In 1930 Crider made a more detailed examination of the surface geology, drawing a contour map on (what he considered to be) the top of the Porters Creek clay. In the summer of 1930 Sparagen, "At that time without knowledge of the Julian and Crider reports," worked out a distinct magnetic high. During 1931 the Torsion Balance Exploration Company was engaged to survey the same area. Their report, too, was in substantial agreement with those made from surface reconnaisances.

The Kinnaird composite map shows a dome-shaped closure covering an area of approximately 15 square miles. There is a structural rise toward the center in excess of 50 feet. The dome is faulted northwest-southeast through the center.

Work of the present survey revealed that there is no notable surface closure in the region in which the closure has been shown.

The Porters Creek clay is now known to be at least twice as thick as Crider thought when he made his survey, and, moreover, the character of the clay varies to an extent that he apparently did not realize. He reported a dip of 250 feet between an outcrop on the road in Sec. 23 and another roadside outcrop in adjoining Sec. 25, both in T.14 N., R.14 E. In the Sec. 23 outcrop the highest exposure of Porters Creek is distinctly arenaceous, micaceous, and laminated, characteristic of the upper 50 or 100 feet of the formation and equivalent to the Naheola formation of Alabama. The clay in the Sec. 25 outcrop is extremely fine-grained, non-arenaceous, non-micaceous, and is very indistinctly laminated; it contains small megascopic fossils. These are characteristics of the middle portion of the 500-foot-thick Porters Creek clay.

The Porters Creek formation in Sec. 25 is overlain unconformably by reddish pebble-bearing sand which appears to be the basal sand of the Wilcox. Certain deep auger borings made during clay prospecting in the immediate region indicate that this is not necessarily the case. In fact a careful study of the outcrop shows, by the abnormal abundance of quartz pebbles among other evidences that the contact is not the Midway-Wilcox unconformity, but the contact with the underlying beds of an alluvial or a colluvial blanket of Ackerman sand, lowered through a vertical interval of 300 feet or more not only over the surface of the Porters Creek but over the Betheden formation (bauxitic zone) at the top of the Porters Creek, and over the 40 or 50 feet of the Fearn Springs clay, the basal formation of the Wilcox.

Other than this phenomenon, wherein the coarsely clastic permeable sands are lowered over the fine-grained impermeable plastic clays on the escarpment face, there is no important visable evidence of reverse dip. Barometric and level work on definite horizons (e.g., on top of the Betheden and Fearn Springs formations) verifies a normal dip of 30 to 35 feet per mile approximately S.55 °W. Although small faults are not uncommon in this part of Mississippi, no evidence of faulting was observed, and it is unlikely that there are any faults of magnitude at the surface.

These observations apply, of course, only to surface geology. They are not intended to imply that the Fearn Springs area is unfavorable for the accumulation of oil and gas. Neither are they intended to discredit the work of earlier investigators. Their purpose is to call attention to some of the problems that confront surface geologists in parts of the Coastal Plains.

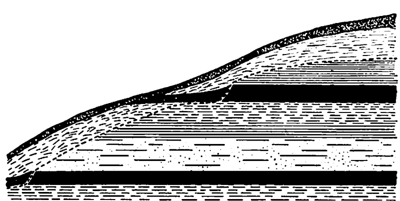


Figure 16.—Generalized section showing the weathering of hard lignite to a smut and the sagging of the strata. The sagging is due to the reduction of thicknesses by weathering and the flow of clay under pressure.

These observations are intended to imply that there is not a surface structure, as mapped, in the Fearn Springs area, and a recommendation is made that a seismographic survey be available before further investments be made on the "Fearn Springs structure."

Many steeply dipping outcrops are exposed in Winston County. Most, if not all of those observed, can be accounted for by cross-bedding and land-slip or slump. Clay and lignite beds commonly dip with the slope of the hill because of pressure differential (Fig. 16), and against the slope of the hill because of landslip (Fig. 17).

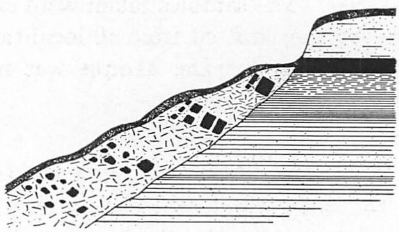


Figure 17.—Generalized section in landslip topography on the escarpment face of a cuesta showing a sequence of beds, clay, lignite, and sand. The oldest slips, lowest, are less prominent and are more highly weathered. In them the underclay is found commonly to be leached to an extremely plastic clay but in non-commercial quantity. Outcrops of lignite on successive slips are often mistaken for successive seams.

A region which appears to justify further investigation is that around Gum Branch in T.16 N., R.12 E. In the area lying between Noxubee and Sulphur Springs creeks immediately southeast of Gum Branch there appears to be faulting to account for the high position of the Betheden formation along the public road in the SE. ¼, SE. ¼, Sec. 27. A mile northeast (NE. ¼, NW. ¼, Sec. 26), the top of the Betheden forms the bed of Noxubee Creek. The difference in elevation is 30.0 feet which is probably not to be accounted for entirely by the irregularity of the old physiographic surface. The Midway-Wilcox contact seems to lie near flood-plain level of Noxubee Creek at the county line in Sec. 2. No attempt was made to work out a structure in this area, and seemingly there has been no previous oil and gas investigation here.

In general the beds of the county reveal a normal dip to the southwest. No definite surface structures were found by this survey. It is entirely possible, however, that subsurface folds and faults exist that are not reflected in younger sediments.

BLEACHING CLAYS

PORTERS CREEK AND ACKERMAN FORMATIONS

There are no bleaching clays of commercial value in Winston County.

Because commercial bleaching clays are produced from the Porters Creek formation elsewhere, and because it was thought possible that the Wilcox and Claiborne beds might contain deposits of clay suitable for bleaching, a careful examination of the strata was made for bentonite or other bleaching material. The samples taken were all more or less silty. Eleven first samples were submitted from 10 localities to P. G. Nutting of the U. S. Geological Survey. One sample was from the Ackerman formation; the other ten represented several fairly definite positions within the upper 300 feet of the Porters Creek.

His testing of bleaching clays in the Survey's laboratories produces results in terms of the ratio of volume of crude test oil filtered to volume of ground clay, the percolation method being used. In reporting the efficiency of activated (acid-leached) clay the optimum degree is indicated.

Nutting's tests (22)

Sample	Bleach Raw		Bleach Treated			
	Water-white	Red	Water-white	Green	Yellow	Red
52	0.7	0.8	1.1	1.3	1.4	1.4
53	0.6	0.7	1.1	1.2	1.3	1.3
54	0.5	0.6	1.1	1.4	1.5	1.5
55	0.5	0.6	1.0	1.1	1.2	1.2
56 C 1	0.4	0.5	1.2	1.4	1.5	1.6
56 C 2	0.4	0.5	1.1	1.3	1.4	1.4
62	0.5	0.6	0.8	0.9	1.1	1.1
63	0.5	0.6	1.1	1.3	1.4	1.4
64	0.5	0.6	0.5	0.6	0.7	0.8
65	0.5	0.6	0.6	0.8	1.0	1.1
66	0.3	0.4	0.5	0.7	0.8	0.8
a	0.7	1.2	......	......	......	......
b	......	......	1.4	2.0	2.4	2.9
c	0.3	0.4	1.4	2.2	2.7	2.9
d	0.3	0.4	1.3	......	......	4.3
e	1.1	1.9	0.6	0.9	1.0	1.2

For comparison:

a. Lowest limit (U. S. Geological Survey) allowable for commercial application, naturally active (raw) clay;

b. Lowest limit (U. S. Geological Survey) allowable for commercial application, activable (acid-treated) clay;

c. Bentonite from Williams Brothers & Wroten Co. plant, Prentiss County;

d. Bentonite from Attapulgus Clay Company mine, Smith County;

e. Most naturally active Porters Creek recorded, Tippah County (a-e from Harry X. Bay, Preliminary investigation of bleaching clays of Mississippi: Miss. Geol. Survey Bull. 29, 1935).

From comparison of the figures in the table, it is obvious that the samples from Winston County are far below commercial standards. Clay from the upper part of the Porters Creek (Samples 55C1, 62C1, 64C1, 65C1) reflects the very silty nature of the beds by low bleaching efficiency. The most efficient samples (52C1, 53C1) are well near the middle of the formation. The most activable sample (56C1) is a subsoil weathered from the clay about 110 feet below the top of the formation. Curiously, this weathered material is more activable than the relatively unweathered Porters Creek clay just beneath (56C2). No samples were collected below the middle of the formation, as the lower half is the bed-rock only in the northeastern corner of the county where it is inaccessible to transportation and is generally covered by widely distributed alluvial terraces of Noxubee, Jones, Loakfoma, Lynn, Little Yellow, and Yellow creeks.

Hole 53-A was drilled at the site of Hole 53 and seven samples, each collected at the bottom of a 5-foot interval, were submitted to Nutting for testing. He reported:

	Raw			
	Water-white	Green	Yellow	Red
C1	0.6	0.7	0.8	0.9
C2	0.5	0.6	0.7	0.7
C3	0.5	0.6	0.7	0.7
C4	0.6	0.7	0.7	0.7
C5	0.6	0.7	0.8	0.8
C6	0.6	0.7	0.7	0.7
C7	0.6	0.7	0.7	0.7

"Despite wide differences in color (tan to blue-gray) and in hardness, these samples show hardly perceptible differences in their bleaching power which is that typical of the Porters Creek clay. It is this remarkable uniformity in decolorizing power of the Porters Creek clay that is so difficult to account for on either the ash or glauconite theory of its origin" (23).

Throughout the southwestern corner of Winston County at the base of the Basic member of the Tallahatta there is a silty bentonitic clay bed a foot or two in thickness. It is of no value in Winston County, but may be a better-developed unit elsewhere.

CERAMIC CLAYS

PORTERS CREEK FORMATION

The Porters Creek formation 500 to 600 feet thick is composed almost entirely of clay. As described in the section on stratigraphic geology, the clay is very dark-gray or nearly black where unweathered, and turns to a dove-gray after exposure to weathering conditions. It is a marine clay, bearing a distinctive micro-fauna and small megascopic fossils, but it does not appear to be very calcareous. Gypsum crystals are common, however, beneath the surface. The typical unweathered clay is a fine-grained plastic carbonaceous, gypsiferous, montmorillonitic clay. Three arbitrary divisions or facies of the Porters Creek clay may be recognized:

1. The basal beds, sandy, calcareous fossiliferous bentonitic clay, transitional from the underlying Clayton formation to the typical Porters Creek clay above;
2. The main body of the formation, very finely silty plastic carbonaceous, gypsiferous, bentonitic (?) conchoidal clay, 350 to 450 feet thick;
3. The upper part of the formation, silty micaceous, ferriferous, carbonaceous, gypsiferous, bentonitic (?) clay, locally replaced by fine-grained sand at the top, 50 to 100 feet thick.

Only the two upper divisions of the formation are present in outcrop in Winston County.

Because of the inexhaustible quantity of these two facies of the clay and because of their uniformity in quality, one sample of each was taken for ceramic testing. Test holes 53A and 55A, and their samples representing, respectively, the main body of the formation and the upper silty phase, show the characteristics of the Porters Creek clay of Winston County. Each test hole and sample represent actually billions of tons of material.

As reported in the section, "Bleaching clays," numerous samples showed the clay to be relatively inactive and relatively inactivable, so that uses for the Porters Creek clay of Winston County must be other than bleaching.

Good exposures of the formation are along the public roads in Lot 4, Sec. 1, T.16 N., R.12 E.; NE. ¼, NW. ¼, Sec. 19, T.16 N., R.13 E., J. C. Boyd, est.; NE. ¼, SW. ¼, Sec. 8, T.16 N., R.13 E; SW. ¼, Sec. 18, T.16 N., R.14 E., Bevill Hill; SE. ¼, SW. ¼, Sec. 8, T.16 N., R.14 E.; W. ½, NE. ¼, Sec. 3, T.15 N., R.13 E.; SW. ¼, Sec. 30, T.16 N., R.14 E.; N. ½, Sec. 8, T.15 N., R.14 E., Singleton Hill; SE. ¼. Sec. 22, and SW. ¼, Sec. 23, T.15 N., R.14 E.; S. ½, NW. ¼, Sec. 3, T.14 N., R.14 E., Schoolar Hill; SE. ¼. Sec. 1, T.14 N., R.14 E.; SE. ¼, NE. ¼, Sec. 23, T. 14 N., R.14 E.; NE. ¼, NE. ¼, Sec. 25, T.14 N., R.14 E.; SW. ¼, NW. ¼, Sec. 11, T.13 N., R.14 E., Haines Mill; etc.

BETHEDEN FORMATION

General

The bauxitic and kaolinitic clays of the Betheden formation of Winston County probably aggregate an amount greatly exceeding the 1,548,000 tons of bauxite of all grades reported for the whole state (8). Three general types of Betheden material are represented:

1. Fine-grained plastic to non-plastic high-alumina clay (kaolinitic);
2. Plastic to non-plastic soft to hard pisolitic high-alumina clay, high in free silica (bauxitic);
3. Relatively non-plastic friable very arenaceous pisolitic to non-pisolitic kaolinitic-bauxitic clay.

The first type is of small extent in the county and is of little commercial value. The second type, an intermediate form ranging between sandy bauxitic kaolin and low-grade bauxite, is present in large quantities in Winston County. The third type, which includes the material called "baukite" (12), is also present in large quantities.

E. P. Rainey Property

On the E. P. Rainey land (NE. ¼, NW. ¼, Sec. 26, T.16 N., R.12 E.) the Betheden lignite and kaolinitic and bauxitic clay crop out in numerous places in the bed of Noxubee Creek. Twelve test holes were drilled and one test pit dug. The overburden of fine-grained sand and silt alluvium varies from 9.0 to 15.0 feet in the flood plain and ranges up to 17.0 feet or more under the terrace north of the stream. In some places no kaolinitic or bauxitic clay was found, because the meanders of the stream have cut the Betheden out locally. Test holes 13 and 15 are on this property.

Although the gradation is complete from the top of the bed downward to the Porters Creek clay, two fairly distinct grades are represented.

The upper grade varies from hard to soft, from yellow to white, from pisolitic to non-pisolitic, from slightly sandy to non-sandy, from lignitic to non-lignitic. It is most lignitic near the top where the large lignitized roots extend downward from the lignite bed. Most of the material is soft, sparingly pisolitic bauxitic kaolin. Of the upper grade there are approximately 67,550 cubic yards proven on the forty acre tract, the average thickness being about 9.0 feet. The lower grade of clay is more sandy and more pyritiferous than the upper; it is micaceous, kaolinitic but non-bauxitic, and non-lignitic. The average thickness is about 5.3 feet and there are approximately 35,500 cubic yards on the forty acre tract. Samples 13P1 and 13P2 are fairly representative of the two grades. Noxubee Creek could easily be diverted to flow through its old sloughs a quarter mile to the south, but even then the water table would have to be kept lowered continuously by pumping if the clay were mined from a pit. Better procedure might be worked out to remove the clay by dredging, in which case the creek might be an asset rather than an impediment.

There is little doubt that the residuum extends under the stream terrace northward (SE. ¼, SW. ¼, Sec. 23, T.16 N., R.12 E.) and into other adjoining lands. Test holes sunk during the wet part of the year were profitless, since the high water table caused incessant caving of the alluvial overburden. Probably in the late summer or early fall thorough prospecting could be done.

About a mile southwest of the deposit just described, there are two exposures of Betheden material similar to the lower grade. These exposures are on the public road which runs from Louisville to Gum Branch (SE. ¼, SE. ¼, Sec. 27, T.16 N., R.12 E). A test hole drilled in the edge of the road reached the unweathered Porters Creek clay in a few feet. The overburden at the outcrop is colluvial sand and extends to a great thickness at one outcrop. No prospecting was done here and no samples were taken.

Mrs. N. E. White estate

East of the Noxubee Creek exposures of the Betheden residuum on the Rainey property the clay crops out on the estate of Mrs. N. E. White (NE. ¼, NE. ¼, Sec. 26, T.16 N., R.12 E.). About 100 yards northwest of the home of Homer White there is a small outcrop of fine-grained plastic kaolinitic clay. The drainage here is excellent, but two test holes drilled on the hill above the outcrop did not show sufficient clay to encourage additional work.

U. S. Resettlement Administration

Two outcrops of plastic kaolinitic clay are found about a half mile apart on property of the Resettlement Administration (Sec. 18, T.16 N., R.13 E.). Because of excessive overburden no test holes were drilled in the area.

Betheden Area

Just east of Betheden (SE. ¼, Sec. 23, T.16 N., R.13 E.) there is one of the largest deposits and certainly the most accessible deposit of bauxitic clay in Winston County. Test hole 165, drilled on the property of Frank Gross at the type locality of the Betheden formation, Livingston Spring, showed 5.8 feet of light-gray to dark-gray sandy bauxitic clay. The test hole was started on the outcrop where the upper part of the bed had been eroded. On the J. J. Kinard property 18.7 feet of sandy bauxitic clay were found in test hole 164. At the base of the test hole the color was grading through light bluish-green toward the dark bluish-gray of the Porters Creek clay. On the two properties there are approximately 281,600 cubic yards of the arenaceous, bauxitic clay. The maximum overburden is 25.0 feet. No attempt was made to grade the material, but samples 165P1 and 164C1, 164C2, 164C3, collectively, are regarded as typical.

Bauxitic or lateritic material was scraped off the surface of a hilltop north of Betheden for use on the Resettlement Administration roads. This is an excellent road material, but there seems to be very little left.

Perhaps better prospects for bauxitic clays are immediately south of Betheden and southwest of there. Lack of time prevented thorough exploration of the area.

Between the Betheden area and the Perkinsville Cemetery area the scant surface evidence of the Betheden residuum suggests that it was largely eroded during the Midway-Wilcox interval.

West of Perkinsville Cemetery

Just west of Perkinsville Cemetery (south side of Sec. 33, T.15 N., R.14 E.) and a few yards north of State Highway 15 at a spring, there is some small float sandy bauxitic material. Although the locality is accessible, the overburden is high, so no prospecting was done.

Southwest of Perkinsville Cemetery

In the heads of the ravines southwest of Perkinsville Cemetery, (Sec. 4, T.14 N., R.14 E.) are exposures of white micaceous kaolin, the material grading downward into fine-grained white cross-bedded sand, and this in turn grading downward into silty Porters Creek clay. The clay probably has no commercial value because of the thick overburden.

There is a shallow outcrop of soft white kaolinitic clay at a spring about 200 yards northeast of the Mrs. Jim Haggard residence (SW. 1/4 of Sec. 4). The clay is slightly sandy.

On the land of Mrs. H. A. Haggard (SW. 1/4, SE. 1/4, Sec. 4) there are three or four outcrops of bauxitic clay within 200 to 300 yards south of the house. Most of the material is whitish, mottled with creamy-yellow. Some is very pisolitic. It varies from soft to hard. All is slightly sandy. The maximum overburden over a large area is not in excess of 40.0 feet. This property will warrant further prospecting if uses are discovered and promoted. The material is similar to that at Betheden and is almost as accessible.

On the land of W. N. Haggard (SE. 1/4, SE. 1/4, Sec. 4) there is an outcrop of yellowish kaolinitic or bauxitic clay in the road. The outcrop is poor and prospecting with augers or pits is necessary.

H. L. Hurt property

On the land of H. L. Hurt (SE. 1/4, NW. 1/4, Sec. 9, T.14 N., R. 14 E.) there is an outcrop of bauxitic clay very similar to that on the Mrs. H. A. Haggard property. The outcrop is 400 yards southeast of the residence and at the confluence of two branches. Farther down the valley the silty concretionary masses of limonite characteristic of the upper Porters Creek formation are found in the stream bed. The overburden is greater than on the Mrs. H. A. Haggard property.

Fair Lumber Company, Sec. 10

Near the center of Sec. 10, T.14 N., R. 14 E., on property of the Fair Lumber Company, there is a small sterile field containing two or three dissected remnants of a bauxitic clay deposit. The material is hard white and relatively free from sand. Most of it is sparingly pisolitic. The pieces of bauxitic clay have been turned up by plow and by erosion so that they are scattered over the surface of the field. Large pieces of the clay were used by the settlers for foundations and chimneys in dwellings. The quantity probably does not exceed a few hundred tons, but prospecting southward might reveal much more material where the overburden has protected it from weathering and erosion.

Fair Lumber Company, Sec. 15

In the S. 1/2, Sec. 15, T.14 N., R.14 E, on property of the Fair Lumber Company are several outcrops of the kaolinitic-bauxitic sand both north and east of Sardis Church, and on both sides and in the bottom of the small steep-sided valley. The material is similar in all visible respects to the "baukite" on the Brown property (described below). It is a little more accessible and is probably in a larger deposit than the Brown deposit. In color it varies from cream to white, but a small amount of yellow and brown material is also present. No test holes were bored and no samples taken.

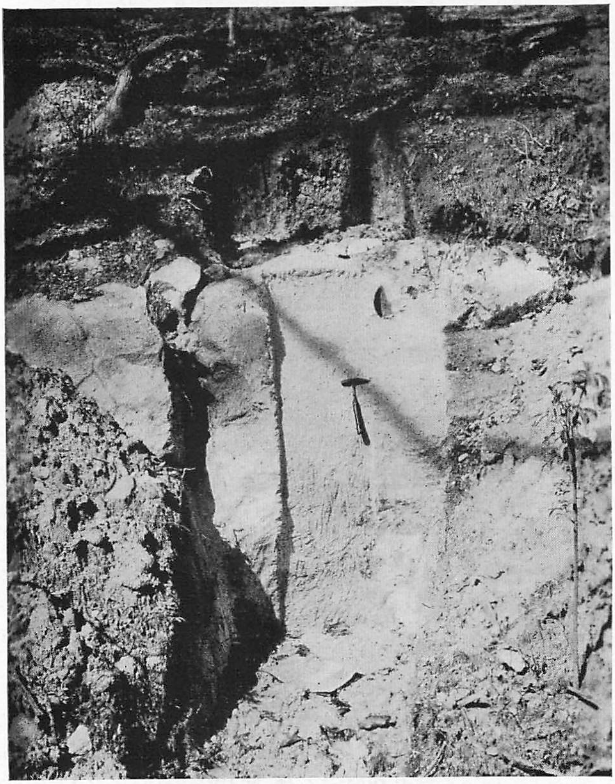


Figure 18.—Test hole 88, a trench exposing a seven-foot face of hard bauxitic clay on the property of the Fair Lumber Company (SE. ¼, NW. ¼, Sec. 22, T.14 N., R.14 E.). The sample for testing was taken from the channel in the middle of the picture.---March 24, 1938.

FAIR LUMBER COMPANY, SEC. 22

Kaolinitic and bauxitic clays crop out in several places in Sec. 22, T.14 N., R.14 E.

On property of the Fair Lumber Company (near the SE. corner, SE. ¼, NW. ¼, Sec. 22) are outcrops of a good grade hard type bauxitic clay, light-tan to creamy-white in color, and slightly sandy. One of these outcrops was faced up (Fig. 18) and sampled (test hole 88) and the State Chemical Laboratory furnished an analysis (No. 155,497) of the material.

Analysis of a sample of bauxitic clay channeled from the seven-foot vertical face of test hole 88, sampled March 24, 1938.

Loss on ignition	13.54
Silica (SiO_2)	45.07
Iron Oxide (Fe_2O_3)	1.17
Aluminum Oxide (Al_2O_3)	39.00
Titanium Oxide (TiO_2)	2.01
Total	100.79

The thickness of this material was not determined. Considerable difficulty was experienced boring down through the loose water-bearing sand on the hills above the outcrops, and numerous holes were abandoned. There may or may not be commercial quantity in this deposit. A few yards downstream from test hole 88 there is a little sandy bauxitic float which may represent the lower part of the bauxitic clay bed.

State-owned lands, Sec. 22

About a quarter mile west of test hole 88 on state-owned land is an outcrop of fine-grained slightly sandy kaolinitic clay in the head of a ravine. A test hole showed 27.8 feet of sand overburden and 9.0 feet of slightly sandy kaolinitic clay, the upper part light-gray and the bottom 1.5 feet bluish-gray. This clay indicates lateral gradation from the material in test hole 88. The hills are steep-sided and the quantity and quality probably do not justify present-day development.

Jones and Sharp property

On the property of Jones and Sharp (E. ½, SW. ¼, SW¼, Sec. 22, T. 14 N., R.14 E.) are several exposures of bauxitic clay. In the south wall of a small valley there crop out a few pieces of hard white pisolitic bauxitic clay, seemingly fairly pure. A test hole put down on the hill above this outcrop penetrated 34.0 feet of sand and was abandoned because of the sand caving. On a hill north of this outcrop is another outcrop of slightly ferruginous bauxitic clay, the extent of which is not known. It is probably similar in chemical and mineralogical composition to the clay in test hole 88 mentioned above.

R. G. Brown, Jr., property

The extremely sandy bauxitic clay that crops out on the R. G. Brown, Jr. property (SW. ¼, SE. ¼, Sec. 21, T.14 N., R.14 E.) has been known for a long time under the name "baukite". Numerous analyses and ceramic tests have been run on the material privately and unusual properties have been claimed for it.

Twenty test holes were drilled on the property, proving approximately 148,000 cubic yards of the sandy bauxitic clay. Eight of the test holes did not penetrate bauxitic material. In the twelve that did the maximum thickness was 19.1 feet and the mean (?) thickness 12.3 feet. Over most of the property the overburden is very thin and averages perhaps 8.0 or 10.0 feet for the entire property.

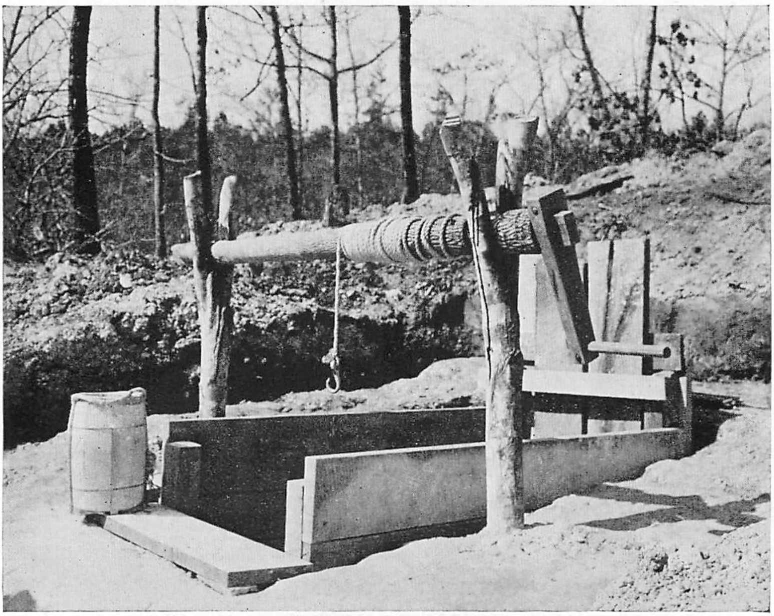


Figure 19.—Test hole 37, a pit in sandy bauxitic clay on the property of R. G. Brown, Jr. (SW. 1/4, SE. 1/4, Sec. 21, T.14 N., R.14 E.). The two boards at the rear are removable to permit sampling.—February 25, 1938.

The bauxitic material is overlain by very plastic fine-grained clay varying from a feather edge to 35.0 feet in thickness. It is underlain by a loose white to yellow fine-grained micaceous, quartz sand containing dark mineral grains. This underlying sand is equivalent to the Naheola of Alabama. The contact between the sand and the arenaceous bauxitic clay is gradational.

This material varies greatly vertically and laterally as other bauxitic materials vary. It is pisolitic to non-pisolitic, firm to loose, and light-gray to yellow or brown. The lower part of the bed contains a greater variety of minerals including some of the less stable forms. Muscovite, though present in the lower part of the bed, is absent in the upper part. The pisolitic portions are higher in alumina than the non-pisolitic portions. The pisolites are more aluminous than their matrix. Just below the middle of the bed there is a definite zone of material more ferruginous than the rest. This material is yellow to brown and is several feet thick in many places. It is not peculiar to this property, for it is well-exposed on the J. J. Moody farm and elsewhere. It is a definite feature of the old soil profile. Probably the upper part of the bed is somewhat more refractory than the lower. Because of this and because of the other variations mentioned, it will probably be best to mine the material in large quantity by mechanical shovel or drag line, thereby obtaining a more uniform raw material.

Test hole records 37 (Fig. 19), 44, 45, 50 and 68 show some of the details of the prospecting.

Fair Lumber Company, SE. ¼, SW. ¼, Sec. 21

A relatively small available quantity of the "baukite" is on the Fair Lumber Company land (SE. ¼, SW. ¼, Sec. 21,T.14 N., R.14 E.). The overburden is greater than on the Brown property, and the deposit extends below drainage a short distance from the eastern line of the property. Test hole 60 shows bauxitic material on this land.

Fair Lumber Company, SW. ¼, NE. ¼, Sec. 21

A single and relatively inaccessible outcrop of very sandy yellowish bauxitic clay is exposed in an old land-slip face on the west side of the valley on the property of the Fair Lumber Company (SW. ¼, NE ¼, Sec. 21, T.14 N., R.14 E.).

J. W. Sullivan estate

The small residual outlier of bauxite and hard bauxitic clay on the Sullivan estate has been mentioned under the heading "Metallic minerals."

About a half mile southwest of this knoll (near the southwest corner of the SW. ¼, SE. ¼, Sec. 28, T. 14 N., R.14 E.) test hole 153 penetrated 9.0 feet of sandy light-bluish-gray (reduced) bauxitic clay lying beneath 16.0 feet of fine-grained plastic clay, and at an equal depth below the water-table. This shows conclusively that the bauxitic materials are not the products of recent weathering phenomena; it is suggestive that they are not the products of diagenetic processes; and it presents no evidence inconsistent with the weathering outlined under the discussion of the Betheden formation. This discovery is strongly suggestive that there is considerably more bauxitic material under these high sand hills than the scattered outcrops indicate.

J. J. Moody property

Bauxitic and kaolinitic clay crops out in numerous places on the J. J. Moody property (SE. ¼, Sec. 33, T.14 N., R.14 E.). One of the best exposures is behind the barn; another excellent one, showing the ferruginous parting, is in the road cut just east of the residence; other good exposures are in the ravines south of the house. The clay shows also a few hundred yards north of the house at the race of the mill pond. There are several outcrops in the pasture about 500 yards northeast of the house. Still another exposure is on the public road at the base of the hill 100 yards northwest of the house. At many of these outcrops lignite or lignite smut is exposed between the bauxitic and the kaolinitic clay and the overlying Fearn Springs clay. At other outcrops the Fearn Springs clay rests directly on the Betheden residuum.

In quality, the material on the Moody place appears to be low in iron and alkalies, and to be variable in silica content. It varies in color from light-bluish-gray in the reduced state to white or yellow or even brown in the oxidized state. Most of the exposed material is white or light-cream. The amount of free silica varies greatly. In the ravines south of the house the material is an arenaceous kaolin and in places has developed great plasticity which results in continuous landslip. Material from the outcrops near the house and in the road appears to be more bauxitic, and sandier. At the outcrops in the pasture northeast of the house, it is little else than a bauxitic sand similar to that at Sardis Church, to that on the Brown property, and to that on the Vernon property (described below). The gradation between types is conspicuous. Eight test holes were bored on the property, three of which gave good samples of the bauxitic clay. Test hole records 102 and 103 show the thickness and relations of the stratum. The tonnage is large and the deposit accessible.

T. S. Foster property

Eleven and eight-tenths feet of sandy, bauxitic clay were struck in test hole 106 on the land of T. S. Foster (SE. ¼, SW. ¼, Sec. 33, T.14 N., R.14 E.) just west of the J. J. Moody residence. The clay was overlain by 32.4 feet of fine-grained plastic clay and that in turn by 11.3 feet of sand.

T. P. Sullivan property

Six and nine-tenths feet of sandy bauxitic clay were penetrated by test hole 101 drilled on the T. P. Sullivan property (NE. ¼, SW. ¼, Sec. 33, T.14 N., R.14 E.) on the edge of the public road. This hole is just west of test hole 103 on the Moody property.

Virgil Vernon property

At Haines Mill, directly in front of the residence of Virgil Vernon, a ledge of very sandy bauxitic clay crops out at intervals for 100 feet along the road. The material is pisolitic, some of the pisolites being very large. The pisolite walls are of a fine grained white material one-sixteenth to one-eighth inch in thickness. The interior of the pisolites is like the matrix, medium-grained sand coated and surrounded by argillaceous matter. The deposit is not so accessible as most of the deposits mentioned above, and the overburden is greater than on other properties. The thickness and extent of this deposit were not determined.

FEARN SPRINGS FORMATION

General

The clays of the Fearn Springs formation are the most important clays of Winston County from the standpoint of thickness, ease of mining, and probable adaptability to wide ceramic uses. In visible quality they range from extremely fine grained plastic ball type clay through various intergrades to good stoneware clay, and through various other intergrades to almost non-argillaceous silt. It is possible that these clays offer greater industrial promise than other similar clays of the South. In some places, they aggregate unusual thicknesses, commonly 25.0 feet or more. They are very plastic, easily shaped with the hand, and appear generally to contain relatively little organic, gypsiferous, or pyritiferous matter. The chief difficulties in the development of the clays are the distance from rail transportation, the variation in quality over spaces of several miles, and the great overburden in places.

The most valuable of the Fearn Springs clays are found in southeast Winston County (T.14 N., R.14 E.).

Dr. T. D. Green old place

On the east side of the nearly abandoned road on the Dr. T. D. Green old place (now owned by the U. S. Resettlement Administration)

(Lot 4, Sec. 12, T.16 N., R.12 E.), is an outcrop of light - tan plastic silty clay. Test hole 17, a pit, penetrated the bed, and the material was divided into two sample types. Of sample 17P1 there are approximately 13,500 cubic yards. Of sample 17P2 there are approximately 12,700 cubic yards. The overburden consists of a few inches of dry humic soil and fragments of ferruginous rock. Roots are numerous in the upper clay and rare in the lower. The one hilltop is nearly flat; drainage is excellent in all directions. The clay bed probably lies at or near the top of several adjacent hills although outcrops were not found. This clay is probably Fearn Springs.

Bevill Hill

The Fearn Springs formation, where exposed on the southwest side of Bevill Hill (NE. ¼, Sec. 24, T.16 N., R.13 E.), is 25.0 feet thick (cf. section). Of this thickness 12.0 feet are evenly bedded micaceous very silty laminated clay which possibly could be used in making heavy clay products. No samples were taken.

Chester Coleman estate

On the Chester Coleman estate (W. ½, NE. ¼, Sec. 3, T.15 N., R.13 E.) are exposed 45.0 feet of the Fearn Springs formation within a few yards of the residence. Much of the interval is fine-grained sandy, finely laminated sparingly micaceous clay containing comminuted lignitic material. It is probably of little or no importance ceramically.

Sumpter Lumber Company, Sec. 22

Along the public road to Yellow Creek Church on the escarpment just west of the Flatwoods (S. ½, Sec. 22, T.15 N., R.14 E.), are several exposures of very silty clay in the Fearn Springs formation. The material is probably of little value. No samples were taken.

J. T. Anderson property, Sec. 22

On the J. T. Anderson property (NE. ¼, SW. ¼, Sec. 22, T.14 N., R.14 E.) there are several outcrops of fine-grained plastic clay, formerly dug and used by the Stewart Pottery in making stoneware. Ten test holes were drilled on the property, showing the deposit to be thick and extensive. In the lower part of the Fearn Springs formation at this point are thin beds of silt alternating with thin beds of silty clay. The overburden is largely loose sand where the clay is thick. The quantity is great. Test holes 27 and 72 show the character of the clay.

Fair Lumber Company, Sec. 22

Just south of the J. T. Anderson property, on land of the Fair Lumber Company (SE. ¼, SW. ¼, Sec. 22, T.14 N., R.14 E.), test hole 58 penetrated 19.8 feet of plastic clay before squeezing of the clay caused abandonment of the hole. No attempt was made to grade the clay in sampling, chiefly because of a high water-table and the consequent inevitable slight contamination with sand from above. The drainage is good for large-scale mining operations. This property and the Anderson property lie one-half to three-quarters mile south of the Sardis Church road on an unkept community road. As on the Anderson place, the overburden is loose sand except for a few inches of ferruginous rock that is to be expected at places on the contact of sand and clay. The quantity of clay on this property would justify large-scale operations.

Fair Lumber Company, Sec. 27

On the John Smith old place, now owned by the Fair Lumber Company (SW. ¼, NE. ¼, Sec. 27, T.14 N., R.14 E.), clay was formerly dug by the Stewart Pottery from pits in the top of a nearly flat-topped hill. Test hole 87, drilled near the old pits, reveals that the upper portion of the original clay stratum has been weathered and eroded. The quantity of clay present will not justify large-scale operations. On the higher hill north of the pits and the test hole a greater thickness of good clay is to be expected, but the overburden is much greater.

R. G. Brown, Jr., property

Overlying the arenaceous bauxitic clay on the R. G. Brown, Jr. property (SW. ¼, SE. ¼, Sec. 21, T.14 N., R.14 E.) is a fine-grained plastic clay of the Fearn Springs formation. Test hole 51 shows a thickness of 16.3 feet lying beneath 7.8 feet of colluvial material. The Fearn Springs and the Betheden clays might be won in a single operation. The drainage is excellent, and the overburden low over the entire property. The Fearn Springs clay is absent on the north side of the property. On the south side the hills slope upward to the adjoining Fair Lumber Company property where greater thicknesses of the clay are recorded.

Fair Lumber Company, Sec. 28

For the last several years the Stewart Pottery (Fig. 20) has been obtaining its stoneware clay from the roadside on property of the Fair Lumber Company (NW. ¼, NE. ¼, Sec. 28, T.14 N., R.14 E.). About 5.0 feet of clay are removed from each temporary pit and mixed in the processes of handling and pugging. A few inches of dark lignitic clay at the top of the bed are rejected and the subsequent mixing of the finer upper part of the bed with the siltier lower part gives a satisfactory

Figure 20.—Stewart Pottery, 10 miles east of Louisville, Winston County.---March 23, 1937.

stoneware clay. Test hole 61 (Fig. 21) revealed that the deposit from which the clay used by the pottery is taken is 8.3 feet thick, and that it is underlain by a much greater thickness, 14.2 feet or more, of stoneware and ball clay. Because of the sand overburden it was impossible to keep the samples perfectly clean. Test hole 61 yielded samples in reduced chemical state. Test hole 154, drilled down-hill 75.0 feet northeast of test hole 61, showed oxidation colors throughout. The clay on this property is thick and is, seemingly, of good grades. The overburden of loose sand varies greatly and because of this variation, the property is probably less attractive than other properties in the area.

J. W. SULLIVAN ESTATE

An outcrop of plastic clay of the Fearn Springs formation was found by John M. Young, a tenant, in the Sullivan pasture on the east slope of the ridge, and about 200 yards northeast of the house. This outcrop is in the NE. ¼, SE. ¼, Sec. 28, T.14 N., R.14 E. The slope of the hill is relatively gentle; the drainage is good. Prospecting with augers may reveal that this is a good location for opening a pit. Bauxitic clay or bauxite (Betheden formation) possibly underlies the Fearn Springs clay here.

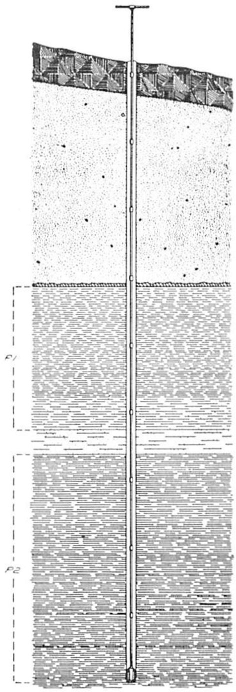


Figure 21.—Diagramatic section of test hole 61 on the property of Fair Lumber Company (NW. 1/4, NE. 1/4, Sec. 28, T.14 N., R.14 E.), showing the relationship of overburden and clay and the method of sampling. The sand is basal Ackerman; the clay, Fearn Springs. Each section of auger stem is four feet in length.

Very plastic clay of the Fearn Springs formation crops out almost continuously for several hundred yards along the channel of Whites Branch on the J. W. Sullivan estate (SW. 1/4, SE. 1/4, Sec. 28, T.14 N., R. 14 E.). Just below the domestic spring there are exposures of bluish-gray slickensided highly plastic clay in both banks of the branch. The clay contains very small lignitic roots showing that its extreme fineness of grain is due in part, at least, to leaching by roots and organic acids. Test hole 153 showed the clay to be 16.0 feet thick (the hole was not started at the top of the Fearn Springs), the upper 6.0 feet (sample P1) being free of any noticeable silt; the lower 10.0 feet are more or less sandy and slightly ferruginous as indicated by red mottling. The clay stratum is underlain by light-gray sandy bauxitic clay. Inasmuch as the clay is found at stream level, and a few feet above, in the small steep-walled valley of Whites Branch, the mining of more than the one or several thousand cubic yards in the valley flat itself can be accomplished only by great expense. It is suspected from geologic conditions, however, that the same type of clay will be found on adjacent properties where conditions for mining are more favorable.

Fair Lumber Company, Sec. 33

On the Fair Lumber Company property (NW. ¼, NE. ¼, Sec. 33, T.14 N., R.14 E.), test hole 150 penetrated 27.0 feet of plastic clay of the Fearn Springs formation. The clay showed oxidation colors in the upper part. A wide flat field lies west of test hole 150. The overburden, largely loose sand, would probably, therefore, be relatively uniform, 25.0 or 30.0 feet thick. Several hundred thousand cubic yards of the clay, all grades, could be recovered. This is possibly one of the best locations in the area for large-scale mining operations.

J. J. Moody property, NE. ¼, Sec. 33

In the north end of the J. J. Moody pasture (NE. ¼, NE. ¼, Sec. 33, T.14 N., R.14 E.) on a hill on the northeast side of Whites Branch are several thick exposures of light-colored (bleached) silty plastic clay. This is a continuation of the clay from the Sullivan estate. Test holes drilled near the Sullivan property line, however, failed to reach the clay because of a high water-table in the sand colluvium. The drainage is excellent and the overburden moderate. The yardage possibly will total several hundred thousand. No samples were taken.

J. J. Moody property, NW. ¼, SE. ¼, Sec. 33

Test hole 103 drilled just across the property line east of test hole 101 (T. P. Sullivan place) on the slope of the hill on the J. J. Moody place, (NW. ¼, SE. ¼, Sec. 33, T. 14 N., R. 14 E.) showed 15.6 feet of plastic clay. The main body of the deposit (Figs. 9, 21) lies to the west on the Sullivan property. There are surface indications that a considerable body of the same clay lies in the northeast part of this same forty-acre tract just north and northeast of the water mill.

J. J. Moody property, SW. ¼, SE. ¼, Sec. 33

Just behind the J. J. Moody residence (NW. ¼, SW. ¼, SE. ¼, Sec. 33, T.14 N., R. 14 E.) are several exposures of red-gray mottled plastic clay similar to that on the T. P. Sullivan and T. S. Foster properties. Test hole 102, low on the hill, penetrated 4.6 feet of this clay; test hole 104, higher on the hill, southward, penetrated 21.3 feet of highly plastic red-gray mottled and gray clay. Test hole 104 was abandoned, because of the clay squeezing in on the auger. Another test hole drilled still higher was abandoned, because of sand caving in at a high water-table. The quantity of clay is great on this and adjoining lands.

T. S. Foster property

On the T. S. Foster property (SE. ¼, SW. ¼, Sec. 33, T.14 N., R. 14 E.) 32.4 feet of plastic clay, red-gray mottled to gray, were penetrated by test hole 106. The overburden is 11.3 feet at this point. There is, therefore, a great quantity of clay in this hill available under thin overburden. The clay exhibits visual characteristics similar to those of the Fearn Springs clay from adjoining properties.

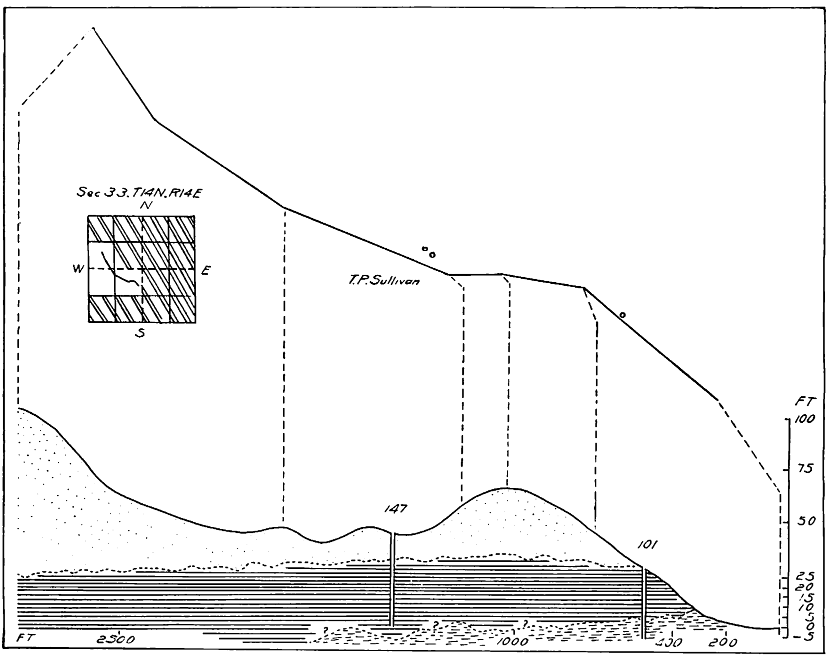


Figure 22.—Cross-section and ground plan of clay deposits along the public road two miles northwest of Fearn Springs (Sec. 33, T.14 N., R.14 E.).

T. P. Sullivan property

Six test holes were drilled on the T. P. Sullivan property (NE. ¼, SW. ¼, Sec. 33, T.14 N., R.14 E.). Three test holes encountered 27.6

18.3, and 31.0 feet of sand which caved, preventing penetrations of the clay stratum. Two test holes, 101 and 147, encountered 25.1 and 32.2 feet, respectively, of the Fearn Springs formation. The clay in test hole 101 was chiefly red-gray mottled, and that in test hole 147 was dark-gray, containing beds of silt, some lignite, and a seam of rock. These facts are almost conclusive that the red-gray mottling is due to adjustments to pressure on the fringes of the hill, and the consequent rapid circulation of ground water. Because of the sand overburden and the high water-table it was impossible to obtain samples free from contamination in test hole 147. The T. P. Sullivan property is the most readily accessible deposit of Fearn Springs clay examined in Winston County. Figure 22 shows the ground plan of the property and the inferred geologic conditions.

J. T. Anderson property, Sec. 3

The type locality of the Fearn Springs formation (Figs. 8, 10) is on the public road on the J. T. Anderson property (SE. 1/4, NE. 1/4, Sec. 3, T.13 N., R. 14 E.), just west of Fearn Springs postoffice. Test hole 119 penetrated 48.8 feet of silty clay and silt, the total thickness of the formation on this property. The clay is probably of no economic importance.

ACKERMAN, HOLLY SPRINGS, AND HATCHETIGBEE FORMATIONS, UNDERCLAYS

General

As pointed out in the section on stratigraphic geology, there are repetitions of underclays and lignites in the stratigraphic sequence. The Fearn Springs formation with its important clays and minor seams of lignite is a poorly developed cyclothem. The Ackerman, the Holly Springs, and the Hatchetigbee are fully developed cyclothems or formations of the Wilcox series. In each of the three are several lignite seams and underclays. Because the Holly Springs and Hatchetigbee areas are less accessible to transportation than the Ackerman area, studies of the underclays were confined to those of the Ackerman formation. The underclays of the Holly Springs and Hatchetigbee formations are probably very similar to the Ackerman underclays in ceramic properties.

In many instances underclays on the outcrop are highly plastic, tenacious, almost free from silt, and free from visible lignitic matter. Test holes and pits, however, reveal that such clays are normally less plastic when removed, are slightly silty, and contain abundant organic matter, most commonly as lignitic roots. In present-day weathering processes, therefore, nature is taking up the beneficiation of clays which were developed to various degrees millions of years ago.

Weathered underclays of this sort are seen at numerous places in road cuts and gullies. Because of the great variation in degree of weathering from point to point, the weathered underclays are not considered here as an individual type, but will be considered in connection with the residual mantlerock.

U. S. Resettlement Administration, Sec. 10

About a half mile north of Poplar Flat Church on the side of the public road (NW. ¼, SW. ¼, Sec. 10, T.15 N., R.12 E.), there is an outcrop of fine-grained very plastic brownish-gray underclay. The clay contains numerous molds of roots, showing that the lignitic matter has oxidized and that there has been slight weathering. The clay is jointed and the joints are lined with an efflorescence of gypsum. Three test holes were drilled on the west side of the road, showing this clay to average approximately 8.0 feet in thickness. The upper 5.6 feet of this interval are the better grade of clay; the lower part of the bed is decidedly silty. There is an approximate yardage of 20,000 available under an overburden up to 15.0 feet. The yardage would be increased greatly if heavier cover were considered. Test hole 75 sampled this underclay. The deposit is on an improved sand-clay road 2.5 miles from the railroad at the Mitchell Brick Company plant.

John Lowry old place

Eight test holes were drilled on the John Lowry old property (SW. ¼, SW. ¼, Sec. 9, T.15 N., R.12 E.), now owned by the U. S. Resettlement Administration. By correlating interval one of test hole 20 with interval eleven of test hole 3, and interval two of test hole 3 with intervals nine and ten of test hole 70, a 98.6-foot section of mid-Ackerman strata is had, showing four lignite seams and four underclays. The uppermost and lowermost clays are, respectively, thin and silty. Test hole 20, two contiguous trenches (Fig. 23), revealed a lower underclay 7.8 feet thick, and an upper underclay 7.7 feet thick. The lower clay appears to have less organic matter than the upper. Landslips are common in the vicinity of test hole 20. Mining of these clays would probably be restricted to small areas where landslips have not concealed the strata and where the hills are not too steep. Any large-scale recovery of the clays would have to be by underground mining.

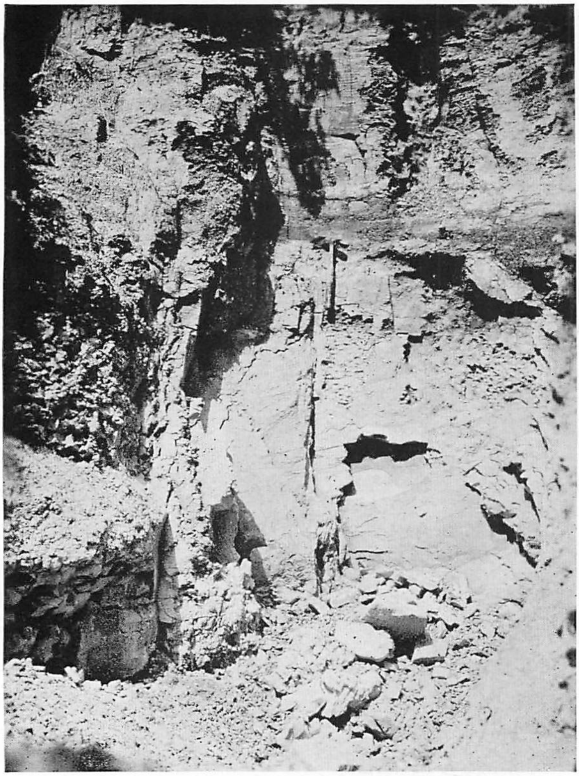


Figure 23.—Lower trench of test hole 20 on the John Lowry old place (U. S. Resettlement Administration) (NW. ¼, SW. ¼, Sec. 9, T. 15 N., R.12 E.), showing position of samples taken for testing. ---June 30, 1938.

J. NAT WOODWARD PROPERTY

The lignite at the J. Nat Woodward old lignite entry (NW. ¼, NE. ¼, Sec. 21, T.15 N., R.12 E.) is underlain by a 12.0-foot bed of underclay; this, in turn, by another seam of lignite; and this, in turn, by another underclay 4.5 feet or more. The section is correlated precisely with test hole 20. Samples 20P1 and 20P2 are of the same underclay as 18P2 of the Nat Woodward property. The lower underclay is below drainage. The upper clay appears to be relatively uniform throughout its thickness and to be of finer grain than in test hole 20. A few thousand cubic yards could be recovered by working along the edge of the steep hills. If the upper lignite is ever mined, the upper few feet of the clay could be removed from the drifts. Test holes 18 and 23 described the clay and lignite at the old lignite entry.

FAIR LUMBER COMPANY; E. A. BARNHILL

On properties of Fair Lumber Company and E. A. Barnhill (SE. ¼, SE. ¼, Sec. 34, T.15 N., R.13 E.; NE.¼, NE. ¼, Sec. 3, T.14 N., R.13 E.) are several beds of plastic clays separated by thin soft lignite seams. The beds are believed to be in the Ackerman formation. The upper bed lies just above the flood plain of Murphy Creek. Where it crops out in the highway cut on the west side of the bottom, it has been dug and used for stoneware by the Stewart Pottery. Test hole 92 at this location showed this bed (92C1) to be 3.9 feet thick; it showed a still lower bed of clay 5.1 feet thick from which a sample (92C2) was taken. Five test holes were bored on the two properties showing the clays to be extensive, and revealing aggregate thicknesses of 11.4, 15.3, 6.1, 7.3, and 9.2 feet of the clays. Because of the lack of drainage good samples from some of the holes were not secured. The drainage factor will militate against commercial production of these clays. However, the location on Highway 14 within 7.0 miles of Louisville is favorable. Further investigation along lines suggested by the tests of the samples (92C1; 92C2) is recommended for this vicinity.

ACKERMAN, HOLLY SPRINGS, AND HATCHETIGBEE FORMATIONS SEDIMENTARY CLAYS

GENERAL

An effort to locate clays suitable for the manufacture of cheap light-colored brick to supplant importation of coal-measure clays was made. Some attention was given, also, to clays possibly suitable for red-burning heavy clay products.

MELVIN McCULLY PROPERTY (ACKERMAN)

Test hole 57 (Fig. 24) on the property of Melvin McCully (NW. ¼, SE. ¼, Sec. 15, T.15 N., R.12 E.) revealed a fairly uniform 51.7-foot bed of sedimentary clay in the Ackerman formation. On the outcrop the clay is chocolate-colored, but within the stratum it is dark-gray. The clay is imperfectly laminated micaceous silty, slightly arenaceous, lignitic, and slightly pyritiferous.

There are actually millions of cubic yards of this clay available under 5.0 feet or less of overburden within 2.0 to 3.0 miles of the railroad. The clay is exposed at Drip Spring in Legion State Park (where the various signs of landslip are in evidence), at Poplar Flat Church, and at other places.

Figure 24.—Removing auger from the 76-foot test hole 57 on the property of Melvin McCully (NW. ¼, SE. ¼, Sec. 15, T.15 N., R.12 E.). The efficiency of boring wells with this type equipment has not been exhausted at this depth.---March 10, 1938.

WILLIS WOOD PROPERTY (HATCHETIGBEE)

On the property of Willis Wood (NW. ¼, SE. ¼, Sec. 18, T.14 N., R.10 E.) on the north side of the public road is an exposure of approximately 15.0 feet of silty lignitic leaf-bearing clay in the Hatchetigbee formation. It is less lignitic than the Melvin McCully clay of test hole 57. Test hole 173 is the face of the outcrop from which the sample was taken. The clay is in commercial quantities. It lies on or near the proposed route of Highway 14, and is 18.5 miles from Louisville by the present road.

EVERETTE CLARK PROPERTY

Weathered underclays crop out in numerous places in Winston County. Many of these places, especially where the hill slopes are low, show brownish subsoils overlying the weathered underclays. These subsoils are suitable for the manufacture of common brick. It was thought probable that by mixing the subsoil with the underlying fine-grained plastic clay a superior product could be obtained. For a sample of this type, the Everette Clark property (E. ½, SW. ¼, SE. ¼, Sec. 21, T.14 N., R.12 E.) was selected, because of its proximity to Highway 15, to the Mississippi Power Company transmission line, to the Gulf, Mobile, & Northern Railroad, and to Estes Switch, an abandoned lumber road where many of the workers of the old mill still reside. The material, 18.0 feet in thickness, from which nine "C" samples were taken in test hole 167, is a typical profile in the Ackerman, Holly Springs, and Hatchetigbee belts. Similar material is found, for instance, near the Greensboro School (colored) on the Gulf, Mobile, & Northern Railroad just northwest of the Mitchell Brick Plant, and on the Mrs. J. B. Thackston property five miles northeast of Louisville.

RECENT SURFACE CLAYS

Wide-spread over the central part of Winston County are surface clays, residual and alluvial, suitable for the manufacture of common brick and certain other heavy clay products. In general, the surface residual clays are better drained than the alluvial clays, but the alluvial clays are probably more nearly uniform in quality, both vertically and laterally, than the residual. Most of the residual clays contain at least a small amount of colluvial ferruginous sandstone or siltstone which would have to be removed or ground in making the best products. Clays of both neo-residual and neo-alluvial origin are abundant along the tracks of the Gulf, Mobile, & Northern Railroad through central Winston County. In the past the residual clays were used by several brick plants in Louisville. They are now being used by the Mitchell Brick Company. No samples of these clays were taken.

LIGNITE

EOCENE FORMATIONS

GENERAL

The lignite beds vary in thickness from a feather edge to 12.0 feet or more. They appear to wedge out laterally and to be discontinuous beds rather than sequences of extensive seams; but until close correlations are made, and until detailed work is done, the evidence of lenticular character is not conclusive. The field work in Winston County did lead to specific correlation of outcrops in several instances, but it did not prove the continuity of the seams represented.

The lignite seams are almost invariably overlain by impure sand or silty lignitic clay.

In every examination an underclay was found below the lignite.

The underclays are variable in thickness and in quality. There seems to be no definite relation between the thickness and quality of the underclay and the thickness and quality of the lignite.

Allocthonous lignite (derived from transported vegetable matter) is unimportant; is found only as scattered logs and branches in sedimentary materials.

The quality of the lignite of Winston County varies greatly. Some lignite contains little argillaceous matter; some contains much. All of it is more or less pyritiferous. Grave difficulties experienced in sampling most of the seams render the samples subject to doubt. The only completely successful sample is 18P1 from a clean face. All other samples (save 172C1) were taken from auger holes wherein chances of contamination were especially great, because of mud and sand being carried in by water, and clay and sand being knocked from the upper part of the dry test holes and ground into the samples. Results of tests on these samples will show the quality to be poorer than it actually is rather than better.

Several localities are noted below that show lignite thick enough (four feet or more) and situated favorably enough for mining. However, development will probably depend more on the economic conditions governing production, utilization, and consumption than on any combination of quantity and quality.

J. Nat Woodward property

In the 1920's the Gulf, Mobile, & Northern Railroad timbered and lengthened a drift in a lignite seam on the property of Nat Woodward (NW. ¼, NE. ¼, Sec. 21, T.15 N., R.12 E.) two miles north-northwest of Louisville and a mile northeast of Highway 15 and the railroad tracks. The lignite was taken to the railroad shops in Mobile and tested for use in locomotives. What the results of the tests were, the writer has been unable to learn. The project was abandoned, and no lignite has been removed subsequently, although the mine has remained open.

The roof of the mine has stood up through the decade or more of abandonment, and even though the timbers have rotted and fallen, the salt-and-pepper colored fine-grained slightly micaceous, argillaceous sand roof still bears the marks of tools throughout most of its 100-foot length;

and in but few places has any of the roof caved. Because of its natural argillaceous bond, this unconsolidated sand makes a superb roof for a mine.

The lignite, measured at numerous points within the drift, is consistently 4.0 feet thick. It is dark-brown to black, fairly pure, but contains scattered flakes of clay throughout; it is blocky and coarsely jointed at the bottom and finely jointed at the top where the joints are lined with limonitic film.

No estimate has been made of the quantity of this lignite. There is, undoubtedly, a quantity within the drainage limits sufficient to sustain a fair-sized operation. Care should be taken in further prospecting to test high enough on the hill slopes to penetrate material that might have slumped down over the seam. There is every geological reason to assume that the same seam is present in adjacent hills at nearly the same elevation.

Underlying the lignite is an underclay 12.0 feet thick, and beneath this a second lignite seam, 3.2 feet thick. Because of drainage conditions this thinner seam is of no importance at this locality.

Test hole records 18 and 23 show the geologic relations and the character of the materials.

J. W. McCully property

On the lands of J. W. McCully, S. O. McCully, and adjoining properties (N. ½, Sec. 23, T.15 N., R.12 E.) there is a bed of lignite which, because of its thickness, its proximity to transportation, and its extent, appears to offer good opportunities for development.

The area is crossed by the Louisville-Starkville highway and is two miles from Louisville.

The bed crops out in a slumped position at Drip Springs. Brown (4) sampled this outcrop and reported "The analysis shows this to be higher in fixed carbon than any other Mississippi lignite analysed, and it is the best of the Winston County lignite examined." The analysis is:

Moisture	Volatile Matter	Fixed Carbon	Ash	Total	Sulphur	B. T. U.
11.59	37.49	43.76	7.16	100	1.29	9,819

Test hole records 80, 83, 84, and 161 show the character of overburden and thicknesses of the lignite.

Disregarding the thin lower seam, there is an average thickness of 7.5 feet in the five test-holes drilled, which proves an area of approximately 80,000 square yards or a cubic yardage of 200,000. The average overburden is approximately 20.0 feet.

The underclay is thin and seems to be of poor quality.

The lignite probably extends, under workable conditions, to other properties southward. In Oscar White's well (NE. ¼, SE. ¼, Sec. 22, T.15 N., R.12 E.) a seam that must be the same seam is reported to be 13.0 feet thick between 81.0 and 94.0 feet in depth (31). No attempt to check the bed this far south was made.

J. W. McCully reported that the lignite is water-bearing wherever it is struck east of hole 80. It is true that the thickness varies sharply within a short distance, that the thick lignite is represented only by a smut. This volatilization or decay of lignite certainly must be hastened by its own permeability which is much greater than that of the associated clays.

John Lowry old place

On property formerly owned by John Lowry (SW. ¼, SW. ¼, Sec. 9, T.15 N., R.12 E.), now owned by U. S. Resettlement Administration, are two seams of lignite thought to be of good quality, and known to be of workable thickness. The lower seam, somewhat weathered, was sampled in test hole 3; the upper seam was sampled in test hole 70. The lower seam is 3.8 feet thick, probably more where unweathered. The upper seam is 7.9 feet thick where unweathered, but in several outcrops as a smut it is scarcely more than a foot thick.

The Lowry property is located in the south edge of the steep-sided Noxubee Hills, where the hill slopes are broken by numerous land-slips, and the narrower ridges are drained rapidly of their absorbed water. These are conditions which further prospecting must take into account. They lead to deep weathering of the lignite and this, in turn, to misconceptions as to the thickness as well as the quality of the various lignite beds.

Drainage is adequate for the ordinary room-and-pillar system of mining.

Two lower seams on the property are too thin and too poorly drained to be of economic interest.

The thicker lignite seam in test hole 3 is correlated with that in the J. Nat Woodward entry.

Charles Webster property

Test hole 122 was bored on the property of Charles Webster (SW. ¼, SE. ¼, Sec. 26, T.15 N., R.12 E.) about a mile east of Louisville.

It is 72.8 feet deep, and revealed three seams of lignite 4.9, 3.1, and 6.8 feet, beginning with the uppermost. Although the test hole is situated near the hillcrest, the water table was struck within 12.0 feet of the surface on April 11, 1938. The lignite samples were badly contaminated with the muddy water. Because of low topographic slopes, drifts could not be run in the lignite seams, and the amount of overburden possibly would preclude open cut operations. Probably the most efficient method of reaching the lignite would be by shaft. In view of these difficulties, the most economical mining of the lignite of Winston County would be on such properties as the McCully where the overburden is not excessive, and on such properties as the Nat Woodward, John Lowry, and others in this area where drainage is adequate for underground work.

Northward and eastward the lowest lignite seam should be nearer the surface and offer more favorable conditions for mining. As a trial of this theory, a test hole was sunk near the home of J. T. Ingram, about a mile east of test hole 122. It penetrated materials lying below the lignitic strata, and was, accordingly, at a position both topographically and stratigraphically too low.

E. J. Farish property

On the E. J. Farish property (SW. ¼, NE. ¼, Sec. 26, T.13 N., R.12 E.) test hole 156 penetrated a seam of lignite 3.1 feet thick. The lignite is 40.0 feet below the surface and approximately 13.0 feet lower than adjacent drainage levels. It appears to be of good quality, but the sample was badly contaminated with muddy water.

V. J. Humphries property

On the V. J. Humphries property (NW. ¼, NE. ¼, Sec. 24, T.14 N., R.11 E.) lignite crops out at the well-known Fox Spring. Three test holes were drilled in the flat field above the lignite but failed to penetrate a water-laden silt overlying the seam. To obtain a sample, a trench was dug near the spring and faced up to show the lower 2.0 feet of the seam. The true thickness of the stratum was not determined. It is probably true, therefore, that the lignite seam as a whole is of better quality than sample 172C1 will show. The conditions for mining are not favorable because of rather high overburden of water-bearing silt. The property is remote from transportation facilities.

E. P. Rainey property

On the E. P. Rainey property (NE. ¼, NW. ¼, Sec. 26, T.16 N., R.12 E.) a seam of firm lignite crops out in the bed of Noxubee Creek at several points. This lignite overlies the kaolinitic and bauxitic clays, and lignitic roots can be traced downward into the clays. It is considered to be a part of the Betheden formation. Because the lignite is overlain unconformably by the Fearn Springs and Ackerman formations, and locally by stream deposits, its thickness is thought to vary appreciably over short distances. In test hole 15 the thickness was 4.0 feet, and the seam appeared to be good lignite. The overburden at this point is 13.2 feet. South of Noxubee Creek the lignite is known to be of little consequence, and, in most of the test holes, was missing altogether. It is believed that the lignite north of the Creek is in recoverable quantity. Prospecting on the second bottom was profitless, however, because of a high water-table in the alluvial silt.

The Betheden lignite crops out at Drip Spring and at numerous places around the home of J. J. Moody. Elsewhere in its outcrop belt in Winston County it is missing.

SANDS

The basal sands of the Wilcox are mostly argillaceous. Where they are exposed at the surface they are highly ferruginized, locally indurated to ferruginous sandstone. It is believed that the ferruginous nature of the surface sand is due to surface concentration of iron precipitated from solution, and represents partial or complete replacement of the argillaceous matter. The ferruginous sand, in most places, ranges between 20.0 and 40.0 feet in thickness, forming an excessive overburden even if the sand beneath were suitable for glass manufacture.

Sands are found in two positions in each of the Wilcox cyclothems. The basal sands are fine-grained, medium-grained and coarse-grained, somewhat argillaceous and micaceous, commonly containing quartz and quartzite pebbles and bowlders. The mid-cyclothemic sands are fine-grained and argillaceous.

The mid-cyclothemic sands, such as are found on the Nat Woodward and John Lowery lignite properties, might be suitable for foundry work. No tests, however, are being conducted on them.

The basal Wilcox sands might, by treatment and by screening, be prepared for use in the manufacture of glass. No samples were taken because the sands are invariably argillaceous and because the overburden of ferruginous sand is excessive. The basal Ackerman sand in the Higginbotham Hollow in the edge of Noxubee County is argillaceous and micaceous and is overlain by 20.0 to 30.0 feet of ferruginous sand. In the Watson sand pit (Fig. 13) the white and cream-colored sands near the bottom are decidedly argillaceous.

Test hole 36 on the R. G. Brown, Jr. property (SW. 1/4, SE. 1/4, Sec. 21, T.14 N., R.14 E.) penetrated 29.2 feet of fine-grained white argillaceous, slightly micaceous sand. Sample 36P1 is from this bed. The quantity, undoubtedly, is great, but the accumulation seems to be localized.

BUILDING STONE

Three types of building stone have been utilized to a small extent in Winston County. The ferruginous sandstone and ferruginous claystone have been used effectively in the construction of veneered homes (Fig. 25), stone walls, and steps. The ferruginous claystone is formed

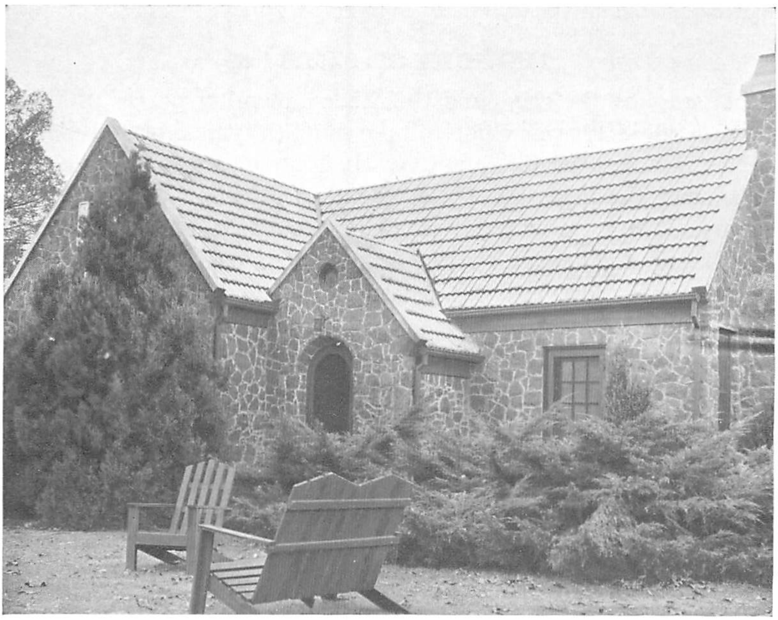


Figure 25.—A veneer of native ferruginous sandstone on the home of George Duck, Louisville.---March 10, 1938.

under favorable conditions at the contact of clay and sand strata. It is rarely as much as 4.0 or 5.0 inches thick and would be, therefore, of little importance. Under other conditions the basal Wilcox sands are locally cemented with limonite, a natural iron cement. The ferruginous sandstone is found under low overburden, but usually associated with a variable quantity of loose sand or friable rock. The material hardens on exposure. It is not of sufficient importance for commercial exploitations, but the local use of this material will probably continue. The third type of stone is the light-colored siltstone of the Basic member of the Tallahatta formation. This rock is found in Winston County only in the southwestern part in an area not readily accessible. It has been used very effectively in the construction of the fireplace in the home of Roger Parks, Louisville. The light colors of the stone, varied by ferruginous stains, make it desirable for ornamental work. The beds vary from several inches to several feet in thickness; they are separated by unconsolidated material. The Basic member contains much less siltstone in Winston than in Neshoba and Lauderdale counties, in both of which the deposits are easily reached. Not one of the three types of stone justifies development in Winston County.

METHODS OF SAMPLING

In sampling the clays and the other mineral resources of Winston County every effort was made to take samples typical of materials that could be mined in usable quantity. It is obviously impossible to predetermine in the field the physico-chemical behavior of a raw material even though an experienced person can frequently foretell with reasonable certainty the behavior of the material under tests. Workers in the field can only assume that one particular clay is suitable for stoneware; or that another clay, free from noticeable silt, is usable as a ball clay; or that a bentonitic clay, containing much silt, is low in bleaching efficiency. It has been necessary, therefore, to take numerous samples, to rely on previously gathered geologic data regarding the beds, to use the best judgment in the selection of samples and the classifying of materials, and to admit the limitations of a complete county-wide mineral survey. Efforts were made to secure from all larger deposits samples of those portions of the beds free from oxidizing conditions. In some instances, ground-water conditions nullified the attempt. In other instances, samples were obtainable only by deep auger holes. In most cases, both incipiently-oxidized and unoxidized samples were taken.

The equipment used in the work (Fig. 26) consisted of: post hole augers, 4, 6, 8, and 9 inches in diameter; ¾-inch pipe 4.0 feet long for auger extensions; cylindrical well-buckets for bailing; rope; heavy truck driveshaft, flattened at end for breaking rock; 2.5-inch fish tail bits for cutting lignite or tough clays; 3 x 4-foot cloths for laying out samples; 20 x 28.5-inch bags of 8-oz. duck for large samples; 11.5 x 14.5-inch bags of 8-oz. duck for smaller samples; 5 x 7-inch bags of domestic for small samples; case knives for cleaning samples in auger; axes, spades;

paper labels and tags; clip-boards; record sheets; 6-foot rules graduated in tenths; and metal tags for marking test hole locations.

Three types of samples were taken. Large samples of approximately 200 pounds, designated by the letter "P" for primary, were considered to be typical of the larger deposits of the various materials.

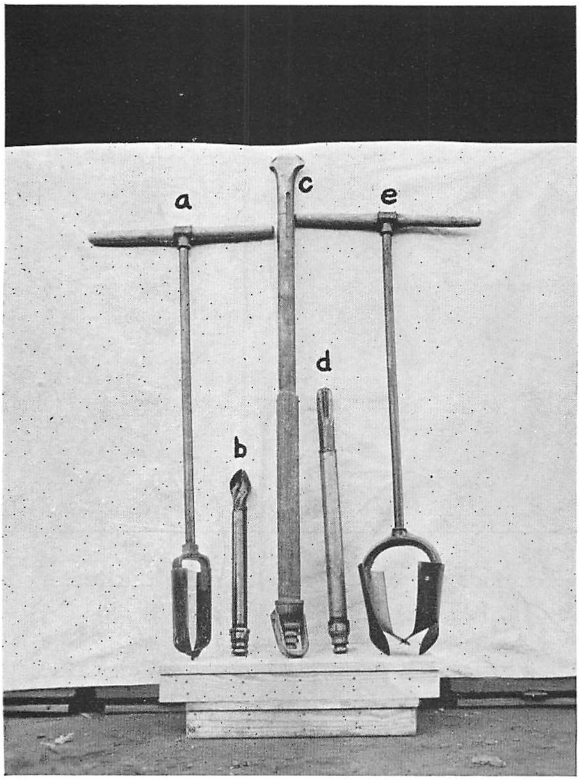


Figure 26.—Some of the tools used in boring test holes: (a) **4-inch post-hole auger;** (b) **fish-tail lignite cutter;** (c) **rock breaker;** (d) **star drill;** (e) **9-inch post-hole auger.**

Numerous smaller samples of ten or fifteen pounds or more were taken from test holes for purposes of comparison or confirmation and were designated by the letter "C"; for the preservation of geologic data and for convenience of the more or less inexperienced sample men, a third type of sample designated by the letter "S" for stratigraphic, was set out. The S-samples, mostly of only a few ounces, were not intended for laboratory testing. Samples (Fig. 27) were labeled with test hole and sample numbers and were accompanied to the testing laboratories by copies of the record sheets.

Figure 27.—Samples prepared for delivery to the testing laboratories. ---March 10, 1938.

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WINSTON COUNTY MINERAL RESOURCES TESTS

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

CERAMIC CLAYS

INTRODUCTION

The test hole records were obviously made in the field. As such they properly belong to the geologic part of this report. They are placed here in the tests part of the report solely for the convenience of the reader. The test hole number, followed by the sample number in the test hole record, constitute the Sample number in the report.

The stratigraphic sequence determined the order of discussion in the geologic part of the report. Logically the same sequence should prevail here. Instead, those samples that the laboratory tests show to be of similar character are treated as a group.

In the geologic part of this report the term "bauxitic" refers to clays having a pisolitic or oolitic structure.

In the tests part of this report, dehydration curves, chemical analyses, and physical properties in the plastic, dried, and fired states show that none of these clays are bauxitic in the ceramic sense, even though they may be so designated in the test hole records.

CLAYS OF THE BETHEDEN FORMATION-HIGH ALUMINA

E. P. RAINEY PROPERTY

TEST HOLE 13 (PIT) RECORD

Location: T. 16 N., R. 12 E., Sec. 26, NE. ¼, NW. ¼ Drilled: Nov. 22- Dec. 3, '37
Elevation: Water level: 16.0 feet.

No.	Depth	Thick.	Sample	Description of strata
1	10.1	10.1		Silt, yellowish to brownish
2	11.0	0.9		Clay, yellowish arenaceous plastic
3	18.0	7.0	P-1	Clay, grayish-white plastic bauxitic; lignitic roots in upper part
4	21.0	3.0	P-1	Clay, grayish-white plastic bauxitic, sandy
5	24.3	3.3	P-2	Clay, grayish-white; sandy plastic; stopped on rock
	24.3	24.3	2	Total

Remarks: Pit abandoned at 21 feet on account of water. P-1 sample taken from wall of pit. P-2 sample taken with augers from bottom of pit.

FAIR LUMBER COMPANY, SEC. 22

TEST HOLE 88 RECORD

Location: T. 14 N., R. 14 E., Sec. 22, SE.¼, NW.¼ Drilled: Mar. 11, 1938
Elevation: Branch level Water Level: dry

No.	Depth	Thick.	Sample	Description of strata
1	8.0	8.0	P-1	Clay, bauxitic hard light-cream to white pisolitic and slightly arenaceous
	8.0	8.0	1	Total

Sample was taken from face of the bed cropping out in west bank of deep branch. Face of bed was cleaned and sample taken from 2-inch thickness.

LABORATORY TESTS OF SAMPLES 13P1, 13P2, 88P1

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Sample No.	Water of plasticity in per cent	Time of slaking in minutes	Drying shrinkage		Modulus of rupture in pounds per square inch	Texture	Color
			Volume in per cent	Linear in per cent			
13P1	25.98	4.0	5.30	1.80	52	Fine	White
13P2	19.88	32.5	6.10	2.08	52	Sandy	White
88P1	22.49	5.0	3.40	1.15	29	Granular	Light cream

SCREEN ANALYSES

Retained on screen	Percent residue for each clay			Character of residue
	13P1	13P2	88P1	
20				Abundance: kaolin nodules with quartz embedded 13P1; pyrite, clay " ironstones" or siderite 13P2. Considerable quantity: quartz 13P1. Small amount: siderite 13P1; quartz, ferruginous material 13P2.
30	6.68	1.49	20.49	Abundance: kaolin nodules 13P1; clay ironstones, kaolin with quartz 13P2; clay nodules 88P1. Considerable quantity: clay ironstones 13P1; quartz 13P2. Small amount: carbonaceous material 13P1. Trace: quartz 13P1; limonite 88P1.
60	10.82	8.35	16.05	Abundance: kaolin nodules 13P1 88P1; quartz, kaolin 13P2. Considerable quantity, quartz conglomerate, siderite 13P2. Trace: mica 13P1; limonite 88P1.
100	8.10	22.28	8.05	Abundance: kaolin nodules 13P1, 88P1; siderite, quartz 13P2. Small amount: quartz 13P1; kaolin 13P2. Trace: mica 13P1; limonite 13P2, 88P1; quartz 88P1.
150	3.64	7.84	2.50	Abundance of kaolin for all clays. Considerable quantity: quartz 13P2. Small amount: quartz 13P1; ilmenite 13P2. Trace: limonite 13P1, 88P1; tourmaline 13P2.
200	3.36	5.71	2.94	Abundance: kaolin 13P1, 13P2, 88P1; quartz 13P2. Small amount: quartz 13P1, 88P1; ilmenite 13P2; kaolinite, quartz 88P1. Trace: limonite 13P1; tourmaline 13P2.
250	.80	1.64	.93	Abundance of kaolin for all clays. Considerable quantity: quartz 13P1, 13P2; limonite 13P2; kaolinite 88P1. Small amount: ilmenite 13P2; limonite, quartz 88P1. Trace of tourmaline 13P2.
Cloth	66.60	52.69	50.96	Clay substance with residue from above.

Note: Screen analyses were determined only on material passing 20-mesh screen.

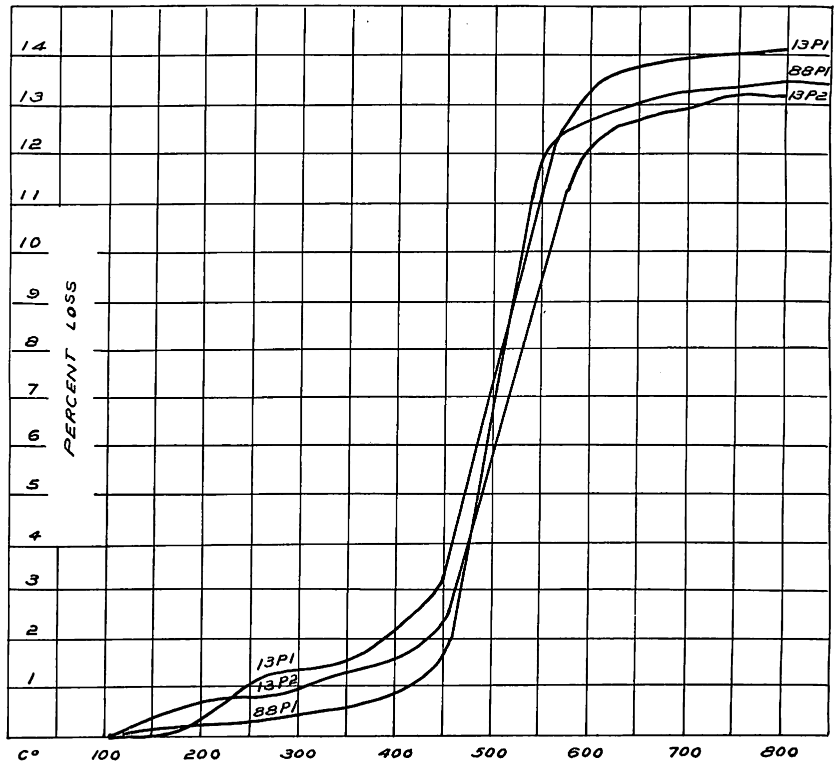

Figure 28.—Thermal dehydration curves of clays 13P1, 13P2, 88P1

CHEMICAL ANALYSES

Sample No.	13P1	13P2	88P1
Ignition loss	14.34	8.45	13.81
Silica—SiO_2	41.76	62.48	41.68
Alumina—Al_2O_3	38.51	19.83	40.03
Iron oxide—Fe_2O_3	1.61	4.86	0.87
Titania—TiO_2	1.65	1.95	2.10
Lime—CaO	0.56	0.36	0.22
Magnesia—MgO	0.29	0.90	0.06
Potash—K_2O	0.08	0.13	Trace
Soda—Na_2O	0.77	0.84	0.38
Sulfur—SO_3	0.31	0.24	Trace
Totals based on dry weight–110°C	99.88	100.04	99.15
Moisture—110°C	0.72	1.07	2.79
Soluble salts—SO_4	0.15	0.20	0.35

SOLUBLE AND INSOLUBLE VALUATION

Sample No.*	13P1	13P2	88P1
Insoluble	78.41	76.75	79.60
Soluble—Al_2O_3	7.08	6.96	8.84
Soluble—Fe_2O_3	0.10	1.02	0.08

THERMAL DEHYDRATION

Temp. C°	Percent loss in weight, Sample Nos.* 13P1	13P2	88P1
100	0.00	0.00	0.00
150	0.10	0.30	0.00
200	0.28	0.53	0.26
250	1.08	0.75	0.27
300	1.33	0.90	0.32
350	1.53	1.28	0.55
400	2.15	1.65	0.88
450	3.27	2.27	1.43
500	7.50	5.83	6.58
550	11.15	9.35	11.95
600	13.35	12.20	12.65
650	13.74	12.65	12.93
700	13.90	12.90	13.18
750	14.00	13.15	13.21
800	14.11	13.15	13.32
850			13.32

*Samples used for soluble and insoluble valuation and thermal dehydration data were washed through 250 mesh screen.

PYRO-PHYSICAL PROPERTIES

SAMPLE No.	At cone	Porosity in percent	Absorption in per cent	Bulk Specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
13P1	04	43.00	26.95	1.56	2.81	13.50	4.72	N. D.	White
	02	42.85	26.85	1.57	2.80	13.50	4.72	N. D.	White
	1	41.88	26.75	1.58	2.76	13.62	4.76	N. D.	White
	3	41.37	26.50	1.59	2.74	14.26	5.01	N. D.	White
	5	38.75	23.08	1.62	2.73	17.37	6.17	N. D.	White
	7	35.82	19.50	1.67	2.72	20.03	7.25	121	White
	9	31.03	15.01	1.90	2.72	29.05	10.83	242	Lt. grey, specked
	11	26.26	13.14	1.99	2.71	31.70	11.93	370	Lt. grey, specked
	13	21.52	10.07	2.12	2.72	34.70	13.24	421	Lt. grey, specked
	13½	19.01	8.77	2.17	2.71	36.93	14.27	N. D.	Lt. grey, specked
	15	17.82	7.65	2.26	2.72	38.30	14.87	480	Lt. grey, specked
	20	4.97	1.91	2.46	2.56	41.30	16.27	1658	Grey, specked
13P2	04	37.78	22.22	1.70	2.78	2.24	.77	N. D.	White
	02	37.52	21.60	1.70	2.78	2.29	.77	N. D.	Light grey
	1	37.00	21.75	1.71	2.78	2.58	.87	N. D.	Light grey
	3	36.48	21.00	1.73	2.77	3.64	1.25	N. D.	Light grey
	5	35.65	20.10	1.78	2.77	5.75	1.97	N. D.	Light grey
	7	34.15	19.48	1.82	2.73	7.00	2.40	483	Light grey
	9	32.84	17.90	1.84	2.72	9.30	3.20	753	Lt. grey, specked
	11	31.20	16.80	1.85	2.70	10.40	3.60	786	Lt. grey, specked
	13	28.90	16.00	1.88	2.64	12.60	4.40	987	Lt. grey, specked
	13½	27.60	15.05	1.90	2.62	13.66	4.79	N. D.	Lt. grey, specked
	14	26.22	13.70	1.91	2.60	15.10	5.31	N. D.	Mottled brown
	15	24.65	12.10	1.94	2.53	15.30	5.40	1013	Mottled brown
	20	3.09	1.46	2.10	2.17	20.10	7.20	Fused	Dark heather
88P1	04	37.40	21.70	1.68	2.66	13.40	4.68	N. D.	Light pink
	02	36.43	21.38	1.69	2.70	13.60	4.76	N. D.	White
	1	36.20	21.30	1.72	2.65	13.85	4.87	N. D.	White
	3	33.33	18.13	1.79	2.54	13.96	4.90	N. D.	White
	5	31.40	17.70	1.84	2.62	19.35	6.94	N. D.	White
	7	30.33	16.80	1.86	2.76	20.64	7.44	174	White
	9	28.45	14.90	1.90	2.65	22.86	8.30	211	White
	11	27.30	14.14	1.91	2.67	24.05	8.78	231	White, tan specks
	13	26.00	13.72	1.93	2.61	25.00	9.14	235	White, tan specks
	13½	24.30	12.26	2.00	2.62	25.17	9.22	N. D.	Lt. grey, tan specks
	14	22.35	11.59	2.02	2.68	25.30	9.27	N. D.	Lt. grey, tan specks
	15	21.74	10.46	2.09	2.64	25.60	9.39	385	Lt. grey, tan specks
	20	17.32	8.01	2.16	2.62	31.10	11.68	691	Lt. buff, tan specks

Softening point P.C.E.: 13P1, cone 34; 13P2, cone 23; 88P1, cone 34.

SUMMARY OF RESULTS

Clays 13P1, 13P2, and 88P1 are essentially of the same mineral composition with the exception of the quartz and the iron compounds in 13P2. The thermal dehydration curves and the soluble and insoluble valuation, data for which were obtained on the clay substance passing through a 250-mesh screen, evidence the similarity of the mineral content. The clay dehydration curves are comparable to those of the mineral kaolinite determined by J. G. Fairchild.* Hydrated alumina, 6.96 percent to 8.84 percent, is common to the three clays. The chemical analyses indicate that the alumina content of 13P1 and 88P1 approaches that of kaolinite. The silica content is too low for all of the alumina to be combined with silica to form kaolinite. It is evident, though, that the bulk of the clay is kaolinite with considerable hydrated alumina, free silica in the form of quartz, and other accessory minerals in small amounts. The principal variation among the three clays is attributed to the accessory minerals and the grain size when the material is ground to pass the 20-mesh screen. The iron-bearing minerals are in a relatively coarse state of division. Screening through a 250-mesh removes 94 percent from 13P1, 79 percent from 13P2, and 91 percent from 88P1.

Clays 13P1 and 13P2 are soft, fine-grained, and friable, and contain a considerable number of pisolites. Clay 88P1 is hard, coarse-grained, and of pisolitic structure, having the appearance of bauxite. The three clays slake partly to a fine state of division, a considerable part remaining as nodules, the size of which is governed by the fineness of grinding; they are not further disintegrated in water. Clay 88P1 in its natural state does not disintegrate in water, and is affected little, if any, by weathering. The clay nodules in 88P1 and 13P1 acting as a non-plastic, account for the unusually low drying shrinkage. In 13P2 the nodules are less numerous; however, the presence of a considerable quantity of quartz tends to reduce drying shrinkage.

The three clays when ground and tempered with water are sufficiently plastic to be molded and possibly extruded and dry readily without warping. The dry strength is too low to enable ware to withstand handling during commercial processes and support the weight of other bricks or shapes during burning. Bond clays, available in Winston County, must be added to give the necessary strength. The fired strength is likewise low, but would undoubtedly be improved by the addition of bond clays.

*Ross, C. S., and Kerr, P. F., The kaolin minerals. U. S. Geological Survey Professional Paper No. 165, Page 166 (1930)

The influence of accessory minerals and grain size is noticeable in the burning behavior. Most obvious are the texture of the clays and the changes in color with advancing heat treatment. The clays approach whiteness in color at low burning temperatures but gradually darken toward maturity.

From the table of pyro-physical properties it will be noted that the three clays are open burning and distinctly porous at cone 15. At cone 20, clays 13P1 and 13P2 are vitreous; clay 13P2 is fused on the surface. Clay 88P1 is not altered appreciably between cones 15 and 20. At cone 20 the linear burning shrinkage of clay 13P1 is approximately twice that of 13P2, while the degree of vitrification between the clays is comparable. The low burning shrinkage of clay 13P2, as the drying shrinkage, is attributed to the high quartz content. For a high alumina clay, the burning shrinkage of 88P1 is unusually low, 11.68 percent at cone 20. Over a firing range of sixteen cones, 5 through 20, the total linear burning shrinkage is 4.74 percent or about one-third of 1 percent per cone. Between cones 9 and 15 inclusive, a firing range of seven cones, the total linear shrinkage is 1.09 percent, an insignificant variation in commercial practice. The combination of properties—high alumina content (40.03 percent), high refractory value (cone 34), with unusually low drying and burning shrinkage—characterizes clay 88P1 as being one of the most desirable in Winston County and probably in the South for use in refractory products.

Samples of clays 13P1 and 13P2 washed through a 250-mesh screen and burned to cone 16 were light gray in color. Clay 88P1 was still lighter but not white enough for use in white ware.

POSSIBILITIES FOR UTILIZATION

Clays 13P1 and 13P2, when blended with the underlying red-burning Porters Creek clay, could be used in the manufacture of face brick. A wide variety of colors, ranging through buff, tan, brown, and gray, with speckled effects, is probable. If these clays are blended with cream-burning to buff-burning bond clays of Winston County, lighter shades can be obtained. With accurate control in manufacturing processes, the latter blend of clays would be suitable for flue lining, chimney block, and medium quality refractory brick and shapes. Clay 13P1, when burned above cone 9 and ground to grog and blended with refractory bond clays, could be utilized in the manufacture of a good quality fire brick, saggers, and refractory shapes. The specific quality of the refractory, and the quality and color of the face brick are, of course, largely dependent on the selection of bond clays and the care exercised during manufacturing processes.

Clay 88P1 is particularly adapted to the manufacture of refractories. In its natural state, and without alteration other than crushing to size, this clay can be used as a non-plastic in the manufacture of No. 1 first quality clay fire brick. Fortunately, high grade bond clays are available near at hand. Although extensive testing,* such as resistance to spalling, deformation under load at high temperatures, and constant shrinkage under repeated firings, have not been conducted on brick utilizing clay 88P1 and local bond clays, all other factors indicate that the materials available could be made into refractory shapes equal to and in some instances exceeding the standard specification for No. 1 first quality clay refractory. The manufacture of fire brick is probably the backbone of the refractory industry, and for this purpose clay 88P1 is well suited. Other products, such as glass pots, saggers, special shapes, kiln furniture, furnace and retort linings, metallurgy crucibles, and refractory patching material, are possibilities within its limits of use. As a non-plastic in light burning bond clays, 88P1 would serve to reduce shrinkage and warpage, giving a blend of clays suitable for manufacture into first quality white, cream, and buff face brick, architectural terra cotta, salt glaze and enamel brick, glazed partition and facing tile, and faience. The wide variety of bond clays in Winston County makes the possibility for utilization of clay 88P1 a certainty.

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*Not in the scope of this report

CLAYS OF THE BETHEDEN FORMATION—HIGH SILICA

R. G. BROWN, JR., PROPERTY

TEST HOLE 37 (PIT, 4 FEET BY 7 FEET) RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW.¼, SE.¼ Drilled: Feb. 18-26, 1938
Elevation: 27.2 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	1.0	1.0		Clay, bauxitic non-pisolitic sandy plastic (above pit)
2	9.0	8.0	P-1	Clay, bauxitic pisolitic sandy; only slightly plastic whitish to light-cream; most pisolites near base of interval
3	12.0	3.0	P-1	Clay, bauxitic pisolitic sandy slightly plastic yellow and white mottled; solid yellow at base
4	13.0	1.0	P-1	Clay, bauxitic non-pisolitic very sandy white
5	17.0	4.0		Sand, argillaceous fine-grained white; grains of rutile or ilmenite and flakes of muscovite; very soft (loose)
	17.0	17.0		Total

Remarks: Test pit, location 119 yards south of NW. corner of SW.¼, SE.¼, Sec. 21, and 27 yards east of west line.

N.B. All elevations shown on test holes in sections 21 and 28, T. 14 N., R. 14 E., are taken from branch crossing on the east boundary line of SW.¼, SE.¼, Sec. 21, about center of line.

R. G. BROWN, JR., PROPERTY

TEST HOLE 44 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW. ¼, SE. ¼ Drilled: Feb. 10, 1938
Elevation: 30.6 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	0.2	0.2		Soil top, dark-brown
2	2.2	2.0		Clay, yellow-stained plastic
3	4.5	2.3	S-1	Clay, yellowish sandy, bauxitic
4	11.8	7.3	C-1	Clay, light-gray bauxitic, sandy
5	11.8			Rock, very hard
	11.8	11.8	1	Total

R. G. BROWN, JR., PROPERTY

TEST HOLE 45 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW.¼, SE.¼ Drilled: Feb. 8, 1938
Elevation: 30.1 feet Water level:

No.	Depth	Thick.	Sample	Description of strata
1	0.5	0.5		Soil top, light-brown fine-grained
2	1.7	1.2	C-1	Clay, grayish iron-stained plastic
3	3.5	1.8		Clay, iron-stained bauxitic
4	10.5	7.0		Clay, light-gray bauxitic
5	10.7	0.2		Sandstone
6	11.8	1.1	C-2	Clay, yellowish highly ferruginous, sandy, bauxitic
7	12.6	0.8	S-1	Sand, light-yellow medium-to fine-grained
8	16.0	3.4	S-2	Sand, pinkish argillaceous, ferruginous fine-grained
9	22.5	6.5	S-3	Sand, creamy-gray to white fine-grained
	22.5	22.5	2	Total

R. G. BROWN, JR., PROPERTY

TEST HOLE 50 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW.¼, SE.¼ Drilled: Feb. 11, 1938
Elevation: 34.1 feet Water level: 17.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	2.1	2.1		Soil top, light-gray
2	4.2	2.1	S-1	Clay, light-gray fine-grained plastic
3	8.6	4.4	C-1	Clay, creamy-white bauxitic
4	9.6	1.0	C-2	Clay, light-yellow bauxitic
5	14.6	5.0	C-3	Clay, darker-yellow sandy, bauxitic
6	15.3	0.7	C-4	Clay, brownish-yellow sandy, bauxitic
7	16.6	1.3	S-2	Clay, yellowish bauxitic, sandy
8	24.5	7.9	C-5	Sand, yellowish argillaceous, micaceous fine-grained
	24.5	24.5	5	Total

Remarks: Hole abandoned at 24.5 feet on account of water.

FAIR LUMBER COMPANY, SE.¼, SW.¼, SEC. 21

TEST HOLE 60 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SE.¼, SW.¼ Drilled: Feb. 15, 1938
Elevation: 27.2 feet Water level: 15.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	2.3	2.3		Soil top, loamy
2	3.0	0.7		Clay, very sandy red
3	10.5	7.5	C-1	Clay, yellow-brown bauxitic
4	11.0	0.5	C-2	Clay, plastic
5	16.0	5.0	C-1	Clay, yellow bauxitic sandy (Baukite)
6	23.5	7.5	S-1	Sand, grayish-white very fine-grained micaceous
	23.5	23.5	2	Total

Remarks: Hole abandoned on account of water and quick sand. Sample C-2 from 0.5 feet near middle of intervals 3, 4, and 5.

R. G. BROWN, JR., PROPERTY

TEST HOLE 68 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW.¼, SE.¼ Drilled: Jan. 17, 1938
Elevation: 45.0 feet Water level: 14.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	0.2	0.2		Soil top, black
2	4.2	4.0		Sand, yellow clayey
3	10.2	6.0	S-1	Clay, gray to yellow and pink smooth-grained plastic
4	23.1	15.9	C-1	Clay, gray to pink bauxitic, sandy (Baukite); iron stained bauxitic clay about 0.1 feet at 20.0 feet; changes to white bauxitic clay (Baukite) at 20.1 feet
5	28.0	1.9	C-2	Clay, cream-colored sandy, bauxitic (or kaolinitic)
6	30.0	2.0		Sand, gray-yellow caving
	30.0	30.0	2	Total

R. G. BROWN, JR., PROPERTY

TEST HOLE 69 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW.¼, SE.¼ Drilled: Feb. 17, 1938
Elevation: 40.6 feet Water level: 7.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	6.7	6.7	C-1	Clay, ocherous stained plastic
2	15.8	9.1	C-2	Clay, yellowish-gray, pink-stained sandy, bauxitic (Baukite); changes to white bauxitic clay (Baukite) at 10 feet
3	18.1	2.3		Clay, yellow sandy, bauxitic (Baukite)
4	25.8	7.7	C-3	Clay, creamy-white very sandy, bauxitic clay (Baukite)
	25.8	25.8	3	Total

Remarks: Hole abandoned at 25.8 feet on account of water.

FRANK GROSS PROPERTY

TEST HOLE 165 RECORD

Location: T. 16 N., R. 13 E., Sec. 23, SW.¼, SE.¼ Drilled: May 30, 1938
Elevation: 8.5 feet Water level: 10.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	1.6	1.6		Soil top, whitish to yellow sandy
2	7.4	5.8	P-1	Clay, dark-gray to light-gray bauxitic, sandy
3	12.4	5.0		Sand, yellow; lumps of light clay
4	22.9	10.5		Clay, Porters Creek, fine-grained; some silt at 22.2 feet
	22.9	22.9	1	Total

Remarks: Base for elevation, flood plain of Dry Creek at culverts, approximately 62 yards NE. of hole. Hole abandoned in Porters Creek clay.

LABORATORY TESTS OF SAMPLES 37P1, 44C1, 45C1, 50C3, 60C1, 68C1, 69C2, 165P1

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Sample No.	Water of plasticity in percent	Time of slaking in minutes	Drying shrinkage		Modulus of rupture in pounds per square inch	Texture	Color
			Volume in percent	Linear in percent			
37P1	16.64	9.5	2.95	1.01	21	Sandy	Lt. greyish-yellow
44C1	16.87	4.5	2.84	0.98	20	Sandy	Lt. cream
45C1	17.86	6.5	3.82	1.32	23	Sandy	Greyish-white
50C3	21.76	5.5	2.54	0.86	N. D.	Sandy	Lt. greyish-yellow
60C1	14.14	29.0	4.30	1.46	105	Sandy	Lt. greyish-yellow
68C1	16.86	8.5	2.32	0.81	39	Sandy	Cream
69C2	20.54	20.0	6.70	2.29	40	Sandy	Cream
165P1	17.58	over 2 hrs.	5.94	2.04	94	Sandy	Lt. grey

CHEMICAL ANALYSES

Sample No.	37P1	44C1	45C1	50C3	60C1	68C1	69C2	165P1
Ignition loss	7.70	8.44	9.45	9.74	4.87	5.63	9.83	5.35
Silica—SiO_2	65.13	63.16	60.14	57.62	73.27	69.65	57.92	73.20
Alumina—Al_2O_3	21.97	24.46	26.05	27.89	16.17	19.49	27.42	16.47
Iron Oxide—Fe_2O_3	0.91	0.90	0.99	2.10	2.20	1.46	0.90	1.20
Titania—TiO_2	1.50	1.55	1.45	1.50	1.15	1.15	1.55	1.20
Lime—CaO	0.56	0.86	0.78	0.43	0.61	0.54	0.94	1.69
Magnesia—MgO	0.31	0.62	0.28	0.36	1.05	1.25	0.25	Trace
Potash—K_2O	0.35	0.18	0.02	0.05	0.08	0.08	0.05	0.52
Soda—Na_2O	0.85	0.35	0.62	0.28	0.47	0.04	0.43	1.11
Sulfur—SO_3	0.05	0.29	0.56	0.28	0.09	0.12	0.98	Trace
Totals based on dry weight—110°C	99.33	100.81	100.34	100.25	99.96	98.85	100.27	100.74
Mositure—110°C	0.62	0.33	0.26	0.29	0.40	0.24	0.47	1.26
Soluble salts—SO_4	0.05	0.15	0.10	0.15	0.20	0.10	0.20	0.15

SOLUBLE AND INSOLUBLE VALUATION

Sample No.*	37P1	50C3	165P1	68C1
Insoluble	84.00	76.47	82.00	69.68
Soluble—Al_2O_3	3.12	10.87	1.65	11.97
Soluble—Fe_2O_3	1.55	3.74	1.22	0.50

*Samples used for soluble and insoluble valuation and thermal dehydration tests were washed through 250-mesh screen.

SCREEN ANALYSES

Retained on screen	Percent residue for each clay 37P1	44C1	45C1	50C3	60C1	68C1	69C2	165P1
20								
30	2.36	.99	1.47	1.07	None	2.70	1.31	2.25
60	24.96	24.96	20.97	17.84	27.92	31.66	20.26	12.80
100	16.34	11.62	10.90	9.13	16.82	16.75	11.02	26.13
150	4.10	2.10	2.32	1.90	4.43	3.73	1.59	8.00
200	2.32	1.45	1.86	1.55	2.38	20.49	1.00	3.67
250	.43	.27	.97	1.25	.31	.47	.34	1.09
Cloth	49.49	58.61	61.51	67.26	48.16	24.20	64.30	46.06

SCREEN ANALYSES (Continued)

Character of residue
Abundance: kaolin nodules, quartz embedded 37P1, 44C1, 45C1, 50C3, 68C1, 69C2; quartz 60C1, 165C1; ferruginous sandstone 60C1; micaceous hematite 68C1. Considerable quantity: quartz 44C1, 45C1, 68C1, 69C2; ferruginous rock 50C3. Small amount: quartz 37P1, 68C1; micaceous limonite 44C1; ferruginous sandstone 45C1; limonitic clay, gray clay, carbonaceous material 165P1. Trace of muscovite 37P1.
Abundance: quartz 37P1, 44C1, 45C1, 50C3, 68C1, 165P1; kaolin 37P1, 44C1, 45C1, 50C3; limonitic clay 50C3. Considerable quantity: kaolin 68C1; quartz, gypsum 69C2. Small amount: limonite 37P1, 45C1; limonitic clay 44C1, 165P1; kaolin 165P1; ferruginous rock 50C3. Trace: gypsum 50C3; limonite 68C1; limonitic sand 69C2.
Abundance: kaolin 37P1, 45C1, 50C3; quartz 37P1, 44C1, 45C1, 50C3, 60C1, 68C1, 165P1. Considerable quantity: kaolin 68C1, 69C2; quartz 69C2. Small amount: limonite 37P1, 44C1, 69C2; kaolin 44C1, 165P1; carbonaceous material 60C1; rutile 69C2. Trace: rutile 44C1, 60C1, 165P1; ferruginous rock 45C1, 50C3; limonite 50C3, 68C1; ilmenite 165P1.
Abundance: quartz in all clays; kaolin 45C1, 68C1. Considerable quantity of kaolin 69C2. Small amount: kaolin 37P1, 44C1, 50C3; limonite 37P1, 44C1, 50C3, 69C2; muscovite, feldspar, kaolinite, rutile, 68C1; carbonaceous material 60C1. Trace: rutile 37P1, 44C1, 60C1, 69C2, 165P1; ferruginous rock 45C1; hematite, kaolinite 50C3; ilmenite 165P1.
Abundance: quartz, kaolin 44C1, 45C1, 68C1, 69C2; limonitic clay 50C3. Small amount: clay 37P1, 165P1; limonite 37P1, 44C1; kaolinite 44C1, 69C1; carbonaceous material 50C3, 60C1; ferruginous rock 50C3; muscovite 60C1, 68C1, 165P1; feldspar 68C1; rutile 60C1, 68C1, 69C2. Trace: rutile 37P1, 44C1, 165P1; ferruginous rock 45C1; kaolinite 50C3.
Abundance: quartz for all clays; kaolin 37P1, 44C1, 45C1, 50C3, 68C1, 69C2; limonitic clay 50C3; muscovite 68C1. Considerable quantity of kaolinite 45C1. Small amount: kaolinite 44C1, 68C1; limonite 44C1; muscovite 60C1, 165P1; rutile 60C1, 69C2, 165P1; feldspar 68C1; tourmaline 165P1. Trace: rutile in all clays except 165P1; magnetite 45C1; kaolinite 50C3; clay, ilmenite 165P1.
Abundance: quartz in all clays except 68C1; kaolin 37P1, 44C1, 45C1, 50C3, 69C2; limonitic clay 50C3. Considerable quantity of kaolinite 37P1, 45C1. Small amount: rutile 37P1, 60C1, 69C2, 165P1; limonitic clay 44C1; tourmaline 165P1. Trace: rutile 44C1, 45C1, 50C3; magnetite 45C1; kaolin 50C3, 165P1.
Clay substance and residue from above.

Note: Screen analyses were determined only on material passing 20-mesh screen.

Thermal dehydration

Temp.C°	100	150	200	250	300	350	400	450	500
37P1	0.00	0.08	0.23	0.38	0.50	0.65	1.03	2.42	11.33
50C3	0.00	0.00	0.10	0.45	0.78	0.90	1.03	1.85	7.65
165P1	0.50	0.80	1.05	1.25	1.45	1.73	2.13	3.68	9.85
68C1	0.08	0.28	0.40	0.50	0.60	0.80	0.90	4.10	7.80

Thermal dehydration (continued)

Temp.C°	550	600	650	700	750	800	850	900
37P1	12.38	12.79	12.95	13.11	13.12			
50C3	10.72	12.32	12.72	12.95	13.21	13.28		
165P1	11.33	11.62	11.86	12.05	12.10	12.16	12.21	12.21
68C1	10.75	12.50	12.75		12.95	13.00		

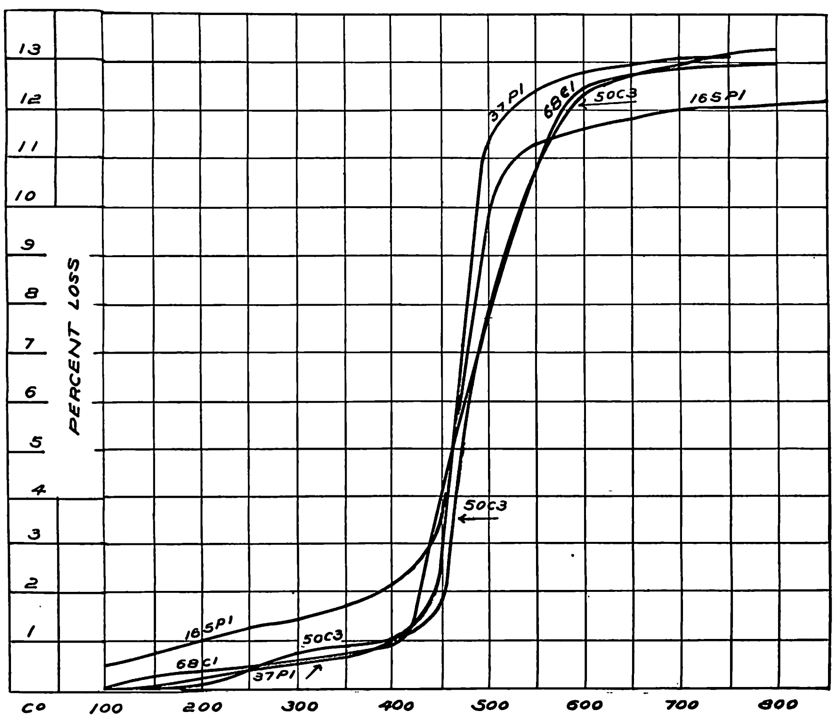

Figure 29.—Thermal dehydration curves of clays 37P1, 50C3, 68C1, 165P1.

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
37P1	04	35.27	20.78	1.67	2.62	-.22	-.07	N. D.	Pink
	02	35.48	21.00	1.71	2.66	-.48	-.17	N. D.	White
	1	35.61	20.98	1.69	2.63	-1.53	-.54	N. D.	White
	3	35.65	20.77	1.72	2.67	-.35	-.13	N. D.	White
	5	34.44	19.24	1.74	2.64	2.07	.70	N. D.	White
	7	38.28	22.24	1.70	2.78	1.40	.47	110	Greyish-white
	9	33.22	18.90	1.75	2.62	2.70	.91	170	Greyish-white
	11	32.22	18.35	1.76	2.59	2.82	.98	217	Greyish-white specked
	13	31.11	17.51	1.76	2.58	4.02	1.39	293	Greyish-white, specked
	13½	30.20	16.63	1.81	2.61	6.33	2.18	N. D.	Greyish-white, specked
	14	31.07	16.32	1.90	2.75	6.93	2.39	N. D.	Greyish-white, specked
	15	32.35	17.88	1.80	2.67	6.78	2.32	376	Greyish-white, specked
	20	26.85	13.82	1.90	2.58	8.35	2.88	627	Buff, specked
44C1	04	36.65	22.10	1.68	2.58	.73	.27	N. D.	White
	02	36.40	22.05	1.67	2.68	1.69	.57	N. D.	White
	1	36.20	21.85	1.66	2.63	1.77	.60	N. D.	White
	3	36.80	22.04	1.69	2.67	2.19	.74	N. D.	White
	5	35.52	21.60	1.70	2.65	3.21	1.11	N. D.	White
	7	37.18	22.46	1.69	2.70	3.32	1.15	N. D.	White
	9	32.80	19.42	1.69	2.50	3.96	1.35	N. D.	White
	11	33.85	19.69	1.72	2.62	4.85	1.66	N. D.	White
	13	33.50	19.22	1.73	2.61	5.45	1.87	253	White, specked
	13½	32.30	18.20	1.76	2.63	7.22	2.50	N. D.	White, specked
	15	32.10	18.10	1.77	2.62	7.22	2.50	255	Greyish-white, specked
	20	27.75	14.60	1.90	2.62	12.11	4.24	520	Cream, specked
45C1	04	37.75	23.07	1.64	2.63	1.27	.44	N. D.	White
	02	37.75	22.60	1.66	2.64	2.18	.74	N. D.	White
	1	38.15	22.70	1.67	2.71	2.48	.84	N. D.	White
	3	36.30	21.80	1.68	2.65	2.18	.74	N. D.	White
	5	36.46	21.31	1.69	2.65	2.92	1.01	N. D.	White
	7	35.70	21.30	1.68	2.64	3.26	1.11	116	White
	9	36.45	20.23	1.78	2.78	6.98	2.39	180	White
	11	34.90	19.68	1.75	2.66	7.02	2.42	226	White, specked
	13	32.35	18.00	1.77	2.62	8.81	3.06	250	White, specked
	13½	32.40	18.18	1.86	2.60	8.33	2.88	N. D.	White, specked
	14	32.20	17.50	1.86	2.71	12.87	4.50	N. D.	White, specked
	15	33.45	18.45	1.79	2.72	11.83	4.14	312	White, specked
	20	26.15	13.29	1.96	2.69	18.24	6.52	664	Cream, specked

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
50C3	04	40.25	25.30	1.59	2.73	1.52	.54	N. D.	Salmon
	02	39.70	24.50	1.60	2.73	2.10	.70	N. D.	Buff
	1	39.60	24.40	1.62	2.70	2.79	.94	N. D.	Buff
	3	39.05	22.97	1.64	2.70	3.80	1.28	N. D.	Buff
	5	38.16	22.68	1.68	2.70	5.30	1.80	N. D.	Buff
	7	37.33	21.98	1.71	2.69	7.86	2.71	N. D.	Buff
	9	34.81	19.70	1.76	2.68	9.27	3.20	N. D.	Buff
	11	33.95	19.06	1.77	2.65	10.85	3.77	N. D.	Rust, specked
	13	32.40	18.60	1.78	2.64	11.05	3.85	N. D.	Rust, specked
	13½	31.90	17.17	1.82	2.61	12.35	4.32	N. D.	Yellowish-brown, specked
	14	30.36	16.68	1.85	2.61	14.04	4.94	N. D.	Yellowish-brown, specked
	15	29.35	15.66	1.86	2.60	15.42	5.46	N. D.	Yellowish-brown, specked
60C1	04	32.50	18.38	1.76	2.61	–5.12	–1.76	N. D.	Pink
	02	31.71	17.54	1.81	2.64	–2.95	–1.01	N. D.	Cream
	1	31.18	17.27	1.80	2.64	–1.79	–.60	N. D.	Cream
	3	31.73	17.45	1.81	2.66	–1.82	–.64	N. D.	Lt.-buff
	5	29.71	15.90	1.84	2.69	1.40	.47	N. D.	Lt.-buff
	7	32.10	17.49	1.86	2.70	.57	.20	271	Lt.-buff
	9	29.20	15.70	1.85	2.63	.02	.01	416	Lt.-buff
	11	28.30	14.60	1.87	2.59	1.46	.50	381	Buff
	13	28.50	14.03	1.96	2.70	7.59	2.60	406	Buff
	13½	29.10	13.55	2.18	2.97	15.78	5.57	N. D.	Dark-buff
	14	26.25	12.90	2.04	2.77	10.84	3.77	N. D.	Dark-buff
	15	25.05	13.40	1.89	2.48	1.21	.44	442	Dark-buff
	20	3.17	1.45	2.16	2.26	15.43	5.46	Fused	Dark-brown
68C1	04	32.15	18.21	1.76	2.60	–3.47	–1.18	N. D.	Pink
	02	32.43	17.96	1.80	2.66	–.35	–.13	N. D.	White
	1	32.20	18.00	1.79	2.64	–.46	–.17	N. D.	White
	3	33.88	19.20	1.76	2.67	–2.39	–.81	N. D.	White
	5	31.40	17.20	1.81	2.65	.46	.17	N. D.	White
	7	32.21	17.87	1.80	2.65	–.68	–.24	190	Greyish-white
	9	29.78	16.46	1.81	2.58	–1.51	–.54	194	Greyish-white
	11	30.33	16.59	1.82	2.62	.49	.17	268	Greyish-white, specked
	13	28.88	16.03	1.80	2.53	.11	.07	243	Greyish-white, specked
	13½	28.80	15.43	1.87	2.63	.28	.10	N. D.	Greyish-white, specked
	14	28.50	14.81	1.86	2.60	.35	.13	N. D.	Greyish-white, specked
	15	29.95	16.44	1.82	2.60	.86	.30	276	Greyish-white, specked
	20	25.50	13.58	1.87	2.52	2.92	1.01	403	Buff, specked

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
69C2	04	37.80	23.10	1.64	2.64	1.73	.57	N. D.	Pink
	02	37.90	23.20	1.64	2.65	2.09	.70	N. D.	White
	1	37.60	22.91	1.67	2.68	4.11	1.42	N. D.	White
	3	37.95	23.10	1.65	2.65	2.58	.87	N. D.	White
	5	35.15	20.43	1.72	2.66	5.96	2.04	N. D.	White
	7	36.18	21.84	1.71	2.72	4.08	1.39	360	White
	9	31.60	17.70	1.77	2.56	7.36	2.53	475	Greyish-white, specked
	11	31.45	17.40	1.79	2.63	9.67	3.34	504	Greyish-white, specked
	13	29.76	16.55	1.79	2.56	11.11	3.85	506	Greyish-white, specked
	13½	28.40	15.03	1.80	2.64	14.70	5.16	N. D.	Greyish-white, specked
	14	27.25	14.42	1.88	2.69	15.23	5.38	N. D.	Greyish-white, specked
	15	28.75	15.04	1.91	2.70	17.43	6.21	594	Greyish-white, specked
	20	23.60	12.90	2.02	2.64	20.91	7.56	855	Buff, specked
165P1	04	33.25	19.24	1.71	2.55	-3.35	-1.15	N. D.	Pink
	02	34.40	19.73	1.71	2.63	-2.56	-.87	N. D.	White
	1	33.60	19.50	1.73	2.59	-3.36	-1.15	N. D.	White
	3	35.75	20.56	1.73	2.70	-1.57	-.54	N. D.	White
	5	31.65	17.90	1.76	2.58	-.58	-.20	N. D.	White
	7	30.04	17.00	1.79	2.65	.00	.00	282	White
	9	29.50	16.63	1.79	2.59	.86	.30	412	White
	11	28.40	15.77	1.79	2.55	1.34	.47	437	Greyish-white, specked
	13	28.60	15.27	1.89	2.66	4.26	1.46	484	Greyish-white, specked
	13½	27.67	14.64	1.89	2.61	5.77	1.97	N. D.	Cream, specked
	14	29.40	15.86	1.89	2.67	8.26	2.85	N. D.	Cream, specked
	15	29.00	16.46	1.81	2.58	8.30	2.85	466	Cream, specked
	20	22.17	11.43	1.94	2.49	11.18	3.88	753	Greyish-buff, specked
37P1	26	26.40	13.51	1.96	2.66	13.65	4.78		Buff, specked
	31	1.66	.72	2.30	2.34	26.15	9.63		Grey granite
44C1	26	25.20	13.15	1.98	2.67	17.00	6.02		Buff, specked
	31	2.49	1.07	2.33	2.39	29.45	11.00		Grey granite
45C1	26	26.55	13.55	1.96	2.67	21.10	7.60		Buff, specked
	31	1.31	.55	2.40	2.43	32.50	12.28		Grey granite
68C1	26	26.31	13.56	1.94	2.63	7.60	2.60		Buff, specked
	31	1.85	.81	2.28	2.32	20.90	7.52		Grey granite

Supplemental table of pyro-physical properties

Softening point P. C. E.: 37P1, cone 32; 44C1, cone 33; 45C1, cone 33; 50C3, cone 30; 60C1, cone 26; 68C1, cone 32; 69C2, cone 33; 165P1, cone 32.

SUMMARY OF RESULTS

Clays represented by samples 37P1, 44C1, 45C1, 50C3, 60C1, 68C1, 69C2, and 165P1 are characteristic of the so-called Baukite deposits of Winston County. These clays have been erroneously called Baukite, probably because they exhibit certain pyro-physical properties characteristic of the highly siliceous mineral aggregate found near the town of Bauchite in the Austrian Tyrol. Numerous claims have been made concerning the refractory qualities of the Winston County deposits. In general these claims are well founded, but in some instances it seems that enthusiasm has led to exaggeration. Chemical and mineralogical examinations have been made at reputable institutions and some burning tests by laboratories and commercial interests; copies of their reports supplied by one of the owners of the Winston County deposits have been studied in connection with data given here. The method of sampling and the exact source of samples furnished others for examination and testing are unknown, and though the reports are in general agreement, the results could have hardly been based on the same sample. The tests and examinations by others are too limited in their scope to be considered sufficiently conclusive for reprinting in this report.

These Winston County clays are essentially mixtures of quartz and white clay. This alone is not unusual; however, the physical state of the two principal components undoubtedly accounts for the properties of the mixtures which distinguish them from artificial mixtures of clay and sand and the usual varieties of sandy clay. The quartz component comprises approximately 35 percent to 50 percent of the mixtures and consists primarily of pitted, angular grains, the larger portion of which is of such size as to be retained on 60-mesh and 100-mesh screens. Rounded grains are common, and quartz grains, both angular and rounded, are found in the residue from each screen and can be distinguished in the interstitial material passing 250-mesh screen. Only a small portion of the total quartz is present as free grains. The larger portion is embedded in a matrix of hard white clay which resists disintegration from grinding and washing. Quartz aggregates, consisting of quartz grains tightly cemented together with hard white clay, are common. The white clay adheres so firmly to many of the quartz grains that it appears to be a part of the quartz and is not removed even in boiling concentrated sulphuric acid.

The clay component consists of hard and soft kaolin. The hard kaolin is virtually non-plastic and comprises the matrix surrounding the quartz grains; it is present also as nodules free from quartz. This phase

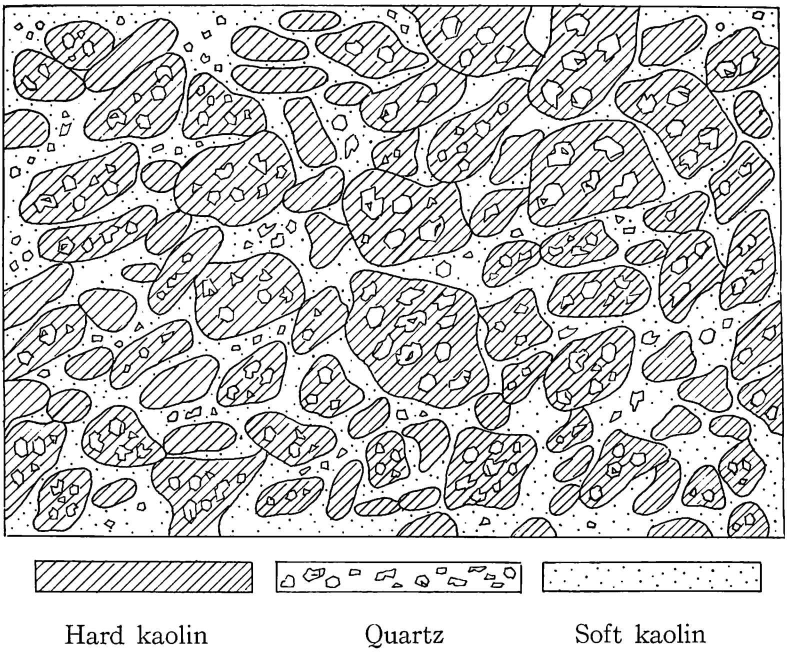

Figure 30.—Diagram showing physical relation of quartz grains to hard kaolin and soft kaolin in the high silica Betheden clays.

of the clay component is the purest and most refractory substance present and probably represents one-half of the total clay substance. The size of the quartz aggregates and hard kaolin nodules seems to be governed by the fineness of grinding, and no further disintegration occurs on soaking in water. The soft kaolin is the plastic phase of the clay component, being extremely fine-grained but only slightly colloidal and appears amorphous under the microscope, though scattered crystals of kaolinite and quartz, and plates of muscovite mica can be identified. The soft clay substance is white to cream in color and seems to be free from iron stain except in samples 50C3 and 60C1.

The thermal dehydration curves of the clay substance (hard and soft kaolin) from samples 37P1, 50C3, 68C1, and 165P1 indicate that halloysite and kaolinite are present as the two principal mineral constituents. The proportion of each evidently varies with the individual clay. Clays 37P1 and 165P1 appear to be higher in halloysite than clays 50C3 and 68C1, which are higher in kaolinite. The two minerals are very similar but when fairly pure would show distinctive dehydration curves. The curves of the several clays are comparable to the curve of halloysite up to a temperature of 450°C. At this temperature the total loss of water is less than that for a typical halloysite and is probably due to dilution by kaolinite which loses relatively little water up to 450°C. The upper portions of the curves show a flattening between the temperature common to halloysite and kaolinite; curves 37P1 and 165P1 tend toward halloysite, whereas curves 50C3 and 68C1 tend more toward kaolinite. The above conclusions were reached by comparing the dehydration curves of Winston County clays with typical curves of halloysite and kaolinite obtained by Ross and Kerr and published in U. S. Geological Survey Professional Paper No. 185-G.

It is interesting to note from the table of soluble and insoluble valuations, the greater solubility, in 18N. sulphuric acid, of alumina in the clay substance of samples 50C3 and 68C1 compared to the lesser solubility of alumina in the clay substance of samples 37P1 and 165P1, and further to note the similarity of the dehydration curves in respect to the solubility of alumina. If there is any definite relation the reason is not apparent.

The chemical analyses show a wide variation in the ratio of alumina to silica, which is undoubtedly due to the variable quartz content. The total alkali, lime, and magnesia averages less than 2 percent; the iron, about 1 percent in the more refractory clays. The total fluxing impurities, including titania, averages about 4.5 percent.

The properties of the several clay-quartz mixtures in the unburned state vary considerably from each other but within narrow limits. The average linear shrinkage is 1.35 percent, and the average modulus of rupture is 49 pounds per square inch. The clays, though low in strength, are sufficiently plastic to be formed and molded into shapes. They dry readily, without cracking or warping.

The pyro-physical properties of the clay-quartz mixtures likewise vary, and again, the variation is within narrow limits. It would be expected that where there are mixtures in variable proportions of plastic and non-plastic clay and quartz, the resultant mixture of any single ratio would possess properties that would vary from the same mixture in a different ratio. This is true of the Winston County clay-quartz deposits; however, the variation in physical properties is not so great as would be expected from mechanical or chemical analyses, inasmuch as in the unburned state, a higher ratio of non-plastic clay would off-set a lower ratio of quartz to clay, even though the total clay content of the mixtures would show a wide variation. During burning, the physical state of the principal constituents is of importance, for while they are in a relatively coarse state of division, there is little tendency for one to react chemically or physically with the other, thereby forming eutectic mixtures having lower melting points than the reacting constituents.

On burning the clay-quartz mixtures of Winston County, the clay and quartz act independently of each other up to cones 30-31, where the quartz begins to melt and takes into solution the more refractory kaolin particles, thereby causing deformation or fusion of the clay-quartz mixture, which is complete at cone 33. The accessory minerals, iron and titania, have little effect in the fusion, for they are in a coarse state of division, whereby their fluxing action is localized. Samples 50C3 and 60C1 are excepted. Other fluxing ingredients, alkalies, lime, and magnesia, are in such small quantities that their fluxing action is of little consequence.

It will be noted from the table of pyro-physical properties that the clays are distinctly open burning through cone 20 and at cone 26; and that they have increased in bulk over the dry unburned state up to cone 11 and higher, at which temperature range the greatest shrinkage would ordinarily be expected; and that the modulus of rupture is generally low and is not appreciably increased with increase of heat treatment. These three points of consideration are directly related to the quartz component of the clay-quartz mixture. It is a well known fact that the heating of quartz is accompanied by a cubic expansion of about 14 percent at 1600°F., and that, on cooling, quartz contracts to its original size. On heating the Winston County clay-quartz mixtures the clay substance tends to shrink, thereby increasing in strength and decreasing in porosity, while the quartz tends to expand, with little other change than a decrease in specific gravity. The force exerted by expanding quartz grains tends to rupture the bonds of the surrounding clay, resulting in a weaker body than would be formed by clay alone. On cooling, the clay substance does not contract as much as the quartz which leaves a void around each quartz grain, thus accounting for the high porosity of the clay-quartz mixture. However, at high temperatures (above 1600°F.) the clay-quartz mixtures are less porous than when cool and are even less porous than the clay alone. For example, if the clay substance has a porosity of 14 percent when burned to cone 11, a 50-50 clay-quartz mixture would likely have a porosity of 7 percent if measured at a temperature equivalent to cone 11, for the quartz component is impervious, it is expanded, leaving no voids; consequently, all of the pore space would be in the clay, which accounts for only half of the bulk of the mixture. The same mixture, when cool, would likely show a porosity of 14 percent, inasmuch as the void space occasioned by the contraction of quartz by 14 percent would account for an additional 7 percent porosity over that of the clay substance. This explanation is given, because it is the tendency to judge the slag-resistant property of a refractory by the porosity of the refractory; and though the Winston County clays show a high porosity when cool, under conditions of service where slag penetration would be a factor, their actual porosity is much less than the figures given in the accompanying table, and, for a 50-50 clay-quartz mixture, approximately 7 percent less than the indicated values.

By virtue of the quartz component, the clay-quartz mixtures would be more resistant to the penetration of acidic slag and silicate melts than a pure kaolin refractory, for under service the clay-quartz mixture would be more nearly impervious than kaolin alone.

Briquettes made from clays 37P1, 44C1, 45C1, and 68C1 were burned to cones 26 and 31 in the high temperature furnace, the optimum temperature being reached in three hours. The results of the test are given in the supplemental table of pyro-physical properties. It is interesting to note that there is practically no alteration of the clays between cones 20 and 26, and that at cone 26 the clays are still open bodied, having an average porosity of 26.1 percent and an average linear shrinkage of 5.25 percent. At cone 31 the clays are vitrous, having an average porosity of 1.84 percent and an average linear shrinkage of 10.1 percent. Of particular interest is the low average linear shrinkage (4.8 percent) between cones 26 and 31, and an accompanying average decrease in porosity of 24.26 percent.

Standard tests to determine resistance to spalling (thermal shock) of the clay-quartz mixtures have not been made. However, practical application of the clays for lining a high temperature furnace, making kiln bagwalls, kiln furniture, and kiln dampers for use in the ceramic laboratory of the Mississippi Geological Survey has demonstrated the excellent resistance of the Winston County clay-quartz mixtures to spalling and to other severe refractory tests. An examination of the clay-quartz lining of the high temperature furnace after continual use for eight months, during which time it was subjected to temperatures exceeding the actual fusion point of the lining mixture, revealed very little alteration in the refractory from its original state. Discoloration had penetrated less than ¼ inch; no change in physical structure was evident. The surface of the lining was glazed, the fusion having penetrated about 1/16 inch. There was no evidence of checking or spalling. There were a few structural cracks which are of little significance.

POSSIBILITIES FOR UTILIZATION

The clay-quartz deposits of Winston County are well suited for use: (1) as a plastic refractory, (2) as the principal ingredient of burnt refractories, and (3) as a non-plastic to blend with plastic dense-burning bond clays of Winston County for manufacture into high-grade light-colored face brick.

A plastic refractory is one that can be formed and burned in the place of utilization. Plastic refractories are used extensively to patch and seal refractory masonry that has cracked or disintegrated in service. They are used to line furnaces, and ladles for molten metals, and, in recent years, in larger scale operations, such as the building of bagwalls and complete glass tanks. The common brand of plastic refractory consists of burnt refractory clay, crushed and screened to proper size, and mixed with small quantities of plastic clay, sodium silicate, and water. The material in a plastic state is packed and shipped in metal drums. The Winston County clay-quartz mixtures possess all the properties of an excellent plastic refractory without pre-burning, processing, or blending with ingredients other than water. The mixtures can be shipped in the crude dry state in carload lots and in paper or cloth bags in smaller lots, thus effecting a considerable saving in packing and shipping costs over competitive commercial brands. The material in its natural state would give excellent service under oxidizing, reducing, or slag-forming burning conditions and at all temperatures encountered in commercial operations.

The clay-quartz mixtures, blended with 10 percent to 30 percent refractory bond clay, are suitable for the manufacture of high-grade refractory brick, shapes, crucibles, saggers, glass pots, kiln furniture, and other kindred products. These products should give good service except where they are subjected to considerable mechanical abrasion. The quality of these products will depend on the refractory properties of the particular clay-quartz mixtures and those of the plastic bond clay selected to blend with them. The variety of both materials in Winston County insures the possibility of making refractories that will meet many requirements. The amount of plastic bond clay added to the clay-quartz mixtures will have a marked effect on the properties of the final product. Increase in plastic clay will increase shrinkage, strength, and resistance to abrasion, but will decrease resistance to checking, cracking, and spalling.

Light-colored face brick of excellent quality can be produced from a blend of clays consisting of 10 to 30 percent clay-quartz and 70 to 90 percent bond clay (see section of this report regarding bond clays). The clay-quartz mixtures will serve as an anti-plastic, helpful in the forming, drying, and burning of the plastic fine-grained, dense bond clays of Winston County.

The present market in the South for high-grade light-colored face brick is hardly touched by producers in the South, and the potential market is hardly realized by them. The better grades of brick are shipped from northern states, especially Ohio. A few southern producers are making a few varieties of buff face brick that are inferior in appearance to Ohio brick. This is a condition that exists because: (1) the raw material now being used by southern producers is not only scarce but is not comparable to the raw material being used by Ohio producers, and (2) the demand for light-colored face brick is so great that southern producers can sell all they make even though the quality and appearance are below northern products competition. Even so, there are more high-grade light-colored face brick shipped into the South than are produced in the South.

This report reveals the fact that raw materials are available in Winston County that will produce light-colored face brick of quality and appearance comparable to the best brick produced elsewhere. The manufacture of high-grade light-colored face brick offers the most promising industrial development of the mineral resources in Winston County.

CLAYS OF THE FEARN SPRINGS AND ACKERMAN

U. S. RESETTLEMENT ADMINISTRATION, DR. J. D. GREEN

TEST HOLE 17 RECORD

Location: T. 16 N., R. 12 E., Sec. 12, Lot 4 Drilled: Dec. 1937
Elevation: 130.0 feet above Noxubee flood plain Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	4.1	4.1	P-1	Clay, a good gradation from weathered brownish-yellow sandy at ground level to nearly unweathered fine plastic bluish-gray slightly sandy at base of interval; surface roots throughout
2	4.3	0.2		Lignite, soft argillaceous
3	8.1	3.8	P-2	Clay, very tough light-gray highly plastic sandy (fine); many fine ancient root marks; contains a few recent roots from above; massive and medium jointed, but with a few indistinct bedding planes and a very few slickensides; top contact fairly sharp; bottom contact sharp, uneven
4	9.2	1.1		Silt, yellow very argillaceous, micaceous, ferruginous, hard, tough; probably represents old "hard pan" of the particular Eocene soil
5	9.8	0.6		Sand, light-colored argillaceous, micaceous fine-grained
	9.8	9.8	2	Total

Remarks: The lower part of interval No. 1 could possibly be used along with the clay of interval No. 3; however, no separate sample was taken. Intervals Nos. 1-3 might be worked together for brick (?); the thin lignite being of little consequence in such a case. 4 x 6-foot pit dug to 8.1 feet.

J. T. ANDERSON PROPERTY, SEC. 22

TEST HOLE 27 RECORD

Location: T.14 N., R.14 E., Sec. 22, NE.¼, SW.¼ Drilled: Jan. 19-Feb. 14, 1938
Elevation: 29.2 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	2.7	2.7		Sand, yellow coarse-grained
2	2.9	0.2		Rock, ferruginous sand
3	5.6	2.7	P-1 (Nos. 3-4)	Clay, gray plastic iron-stained
4	16.0	10.4		Clay, gray plastic
5	17.5	1.5		Clay, yellow ocherous
6	18.4	0.9		Clay, dark-brown plastic slightly sandy Hole abandoned at 18.4 feet in yellow clay
	18.4	18.4	1	Total

Remarks: Location just east of road, 64 yards north of Hurt old farm house. All elevations on Anderson lands, Sec. 22, are taken from Hole No. 29 down slope to S. E. which is 2.0 feet above branch level.

R. G. BROWN, JR., PROPERTY

TEST HOLE 51 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW.¼, SE.¼ Drilled: Feb. 14, 1938
Elevation: 48.0 feet Water level: 10.7 feet

No.	Depth	Thick.	Sample	Description of strata
1	1.5	1.5		Soil top, light-brown
2	7.8	6.3		Sand, yellowish-red medium-grained
3	9.6	1.8	S-1	Clay, brownish iron-stained plastic
4	11.5	1.9	C-1	Clay, pink plastic; streaks of gray clay; streaks of yellow iron-stained clay
5	20.5	9.0	C-2	Clay, gray plastic
6	21.0	0.5	C-3	Clay, gray plastic red-mottled
7	24.1	3.1	C-4	Clay, very dark-gray plastic; stained with yellow muddy water
8	24.1			Rock
	24.1	24.1	4	Total

Remarks: Hole abandoned at 24.1 feet, and no attempt was made to break sandrock and test lower clay, if any.

FAIR LUMBER COMPANY, SEC. 22

TEST HOLE 58 RECORD

Location: T. 14 N., R. 14 E., Sec. 22, SE.¼, SW.¼ Drilled: Jan. 14, 1938
Elevation: 29.2 feet Water level: 8.6 feet

No.	Depth	Thick.	Sample	Description of strata
1	9.1	9.1		Sand, red clayey
2	17.2	8.1		Clay, gray plastic
3	21.3	4.1	C-1	Clay, gray plastic slightly ocherous
4	27.6	6.3		Clay, dark-gray tough plastic
5	28.9	1.3	S-1	Clay, very tough plastic; very yellow with some purple splotches mixed in it for first 0.5 feet
	28.9	28.9	1	Total

Remarks: Elevation taken from Hole 29 in NW.¼, SE.¼, Sec. 22. From 21.3 feet dark-gray tough plastic clay; at 24.6 feet clay is a lighter color. Hole abandoned at 28.9 feet on account of water. Still in tough very plastic yellow stained clay. Clay squeezing in on auger.

FAIR LUMBER COMPANY, SEC. 28

TEST HOLE 61 RECORD

Location: T. 14 N., R. 14 E., Sec. 28, NW.¼, NE.¼ Drilled: Feb. 15, 1938
Elevation: 68.8 feet Water level: 35.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	2.0	2.0		Soil top, loamy
2	13.4	11.4		Sand, very red argillaceous; grading from red sandy clay to yellow sand and to white sand
3	13.5	0.1		Rock, ferruginous sandstone
4	21.8	8.3	P-1	Clay, blue-gray very plastic; upper part very pure carbonaceous; lower part silty
5	23.3	1.5	S-1	Silt, micaceous, argillaceous, yellow to brown
6	37.5	14.2	P-2	Clay, dark-gray very plastic; lower part slightly sandy
	37.5	37.5	2	Total

Remarks: Hole abandoned at 37.5 feet, because of clay squeezing in from the sides on the auger. Interval 3 marks the unconformity between the Fearn Springs formation (below) and the Ackerman formation (above).

J. T. ANDERSON PROPERTY

TEST HOLE 72 RECORD

Location: T. 14 N., R. 14 E., Sec. 22, NE.¼, SW.¼ Drilled: March 1, 1938
Elevation: 21.7 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	2.6	2.6		Sand, red clayey
2	7.2	4.6	C-1	Clay, grayish plastic stained
3	10.1	2.9	C-1	Clay, reddish-yellow-streaked, gray plastic (pure)
4	15.8	5.7	C-2	Clay, yellowish-gray plastic slightly sandy (yellow-stained)
5	17.2	1.4	C-3	Clay, gray plastic, stained with yellow
6	17.5	0.3		Clay, yellow to brown sandy, micaceous (semi-plastic)
7	20.2	2.7	C-4	Clay, yellow to brown sandy, micaceous semi-plastic
8	22.1	1.9	C-5	Clay, gray sandy, micaceous slightly stained
9	23.9	1.8	S-1	Clay, yellow to brown micaceous (semi-plastic)
10	27.3	3.4	C-6	Clay, gray to brownish silty
11	28.0	0.7	C-7	Clay, dark-gray plastic
12	29.5	1.5	C-8	Clay, brownish-gray sandy
	29.5	29.5	8	Total

Remarks: Location approximately 100 yards SE. Hurt old farm house.

U. S. RESETTLEMENT ADMINISTRATION, SEC. 10

TEST HOLE 75 RECORD

Location: T. 15 N., R. 12 E., Sec. 10, NW.¼, SW.¼ Drilled: March 1, 1938
Elevation: 61.0 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	5.6	5.6	P-1	Clay, bluish-gray plastic; gypsum crystals
2	8.3	2.7	C-1	Clay, bluish-gray silty plastic badly yellow-stained
3	8.3			Rock
	8.3	8.3	2	Total

Remarks: Hole abandoned on account of rock. Five additional holes bored near Hole 75 to get the three large sacks, P-1 sample.

JOHN SMITH—FAIR LUMBER COMPANY

TEST HOLE 87 RECORD

Location: T. 14 N., R. 14 E., Sec. 27, SW.¼, NE.¼ Drilled: March 11, 1938
Elevation: 36.3 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	0.3	0.3		Soil, top sandy
2	1.5	1.2		Clay, red sandy, mixed with some gray throughout
3	3.7	2.2	C-1	Clay, gray plastic, containing little sand; some red stain; no mica
4	6.2	2.5		Clay, gray plastic slightly sandy; very little mica
5	7.7	1.5	C-2	Clay, dark-gray, plastic; very little mica
6	17.8	10.1		Sand, yellow fine micaceous, containing some black specks and clay balls
7	19.8	2.0		Sand, creamy fine-grained micaceous
8	20.6	0.8		Sand, white fine-grained micaceous
9	24.0	3.4		Sand, creamy fine-grained micaceous
10	26.4	2.4		Sand, mixed yellow and brown micaceous, clayey, containing some black specks
11	28.0	1.6		Sand, gray-black, yellow clayey, micaceous
12	32.0	4.0	S-1	Clay, gray-red to yellow sandy, micaceous (This bed is a mixture of sand and clay)
	32.0	32.0	2	Total

Remarks: Samples C-1 and C-2 were taken from Hole 87 by drilling several holes through the clay from 1.5 feet to 7.7 feet.

FAIR LUMBER COMPANY, SEC. 34

TEST HOLE 92 RECORD

Location: T. 15 N., R. 13 E., Sec. 34, SE.¼, SE.¼ Drilled: Mar. 17, 1938
Elevation: 9.0 feet Water level: 3.9 feet

No.	Depth	Thick.	Sample	Description of strata
1	3.9	3.9		Clay, sandy yellow medium-grained
2	4.0	0.1		Rock, iron sandy
3	7.9	3.9	C-1	Clay, gray plastic; heavily stained with red
4	8.2	0.3	S-1	Lignite, mixed with black clay
5	9.8	1.6	S-2	Clay, lignitic-stained
6	13.3	3.5	C-2	Clay, dark-gray tough plastic iron-stained
	13.3	13.3	2	Total

Remarks: Elevation from flood plain of Murphy Creek.

T. P. SULLIVAN PROPERTY

Test hole 101 record

Location: T. 14 N., R. 14 E., Sec. 33, NE.¼, SW. ¼ Drilled: March 22, 1938
Elevation: 31.6 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	2.0	2.0		Clay, dark-gray plastic; some very fine sand
2	8.9	6.9	C-1	Clay, plastic light-gray, with red streaks; some very fine sand
3	11.7	2.8	C-2	Clay, plastic dark-gray, red ferruginous-stained
4	14.9	3.2	C-3	Clay, plastic; red highly ferruginous very fine sand
5	16.1	1.2	C-4	Clay, plastic dark-gray ferruginous-stained
6	25.1	9.0	C-5	Clay, plastic dark-gray ferruginous-stained
7	32.0	6.9	C-6	Clay, sandy bauxitic; stained with red muddy water
8	33.2	1.2	C-7	Silt, argillaceous, micaceous, bauxitic
9	33.5	0.3	S-1	Silt, yellow, white micaceous
	33.5	33.5	7	Total

Remarks: Hole abandoned at 33.5 feet. Elevation taken from bridge on Moody Branch. Sample P-1 taken from another hole 2 feet to northwest with 9-inch auger; includes intervals 1 through 6.

J. W. SULLIVAN ESTATE

Test hole 153 record

Location: T. 14 N., R. 14 E., Sec. 28, SW.¼, SE.¼ Drilled: May 9, 1938
Elevation: Water level: 8.7 feet

No.	Depth	Thick.	Sample	Description of strata
1	2.0	2.0	C-1	Clay, dark-gray plastic
2	4.0	2.0	C-2	Clay, dark-gray plastic
3	6.0	2.0	C-3	Clay, dark-gray, red, ironstain very plastic
4	8.0	2.0	C-4	Clay, dark-gray plastic red ironstain; a little sandy
5	10.0	2.0	C-5	Clay, medium-gray plastic sandy
6	12.0	2.0	C-6	Clay, gray plastic red iron-stained
7	14.0	2.0	C-7	Clay, gray plastic very badly red iron-stained
8	16.0	2.0	C-8	Clay, dark to light-gray very sandy semi-plastic
9	18.0	2.0	C-9	Clay, bauxitic light-gray semi-plastic
10	20.0	2.0	C-10	Clay, bauxitic light-gray semi-plastic
11	22.0	2.0	C-11	Clay, bauxitic light-gray
12	23.5	1.5	C-12	Clay, bauxitic, light-gray semi-plastic
13	25.0	1.5	C-13	Clay, bauxitic yellow semi-plastic very sandy
14	29.0	4.0		Sand, yellow medium-grained
	29.0	29.0	13	Total

Remarks: Midway-Wilcox contact represented by interval 8: Fearn Springs above; Betheden below. Abandoned on account of quick sand at 29 feet. Sample P-1 taken of first 6.0 feet of this clay, intervals 1-3.

FAIR LUMBER COMPANY, SEC. 28

TEST HOLE 154 RECORD

Location: T. 14 N., R. 14 E., Sec. 28, NW.¼, NE.¼ Drilled: May 9, 1938
Elevation: 55.6 feet Water level: 26.6 feet

No.	Depth	Thick.	Sample	Description of strata
1	0.9	0.9		Soil, top gray sandy
2	2.4	1.5		Clay, non-plastic sandy yellow ferruginous-stained
3	7.8	5.4		Clay, plastic gray, with reddish ferruginous-stained spots
4	10.4	2.6		Sand, clayey, micaceous, yellow iron-stained
5	16.0	5.6	C-1	Clay, very plastic dark-gray; yellow iron-stained joints; very small lignitic-stained spots
6	17.8	1.8	C-2	Clay, plastic slightly sandy, micaceous dark-gray, badly stained with yellow and red; very small yellow ferruginous-stained rock at 17.4 feet
7	18.9	1.1	C-3	Clay, semi-plastic sandy, micaceous, badly stained with yellow
8	19.0	0.1		Rock
9	19.5	0.5		Clay, non-plastic sandy, rocky yellow ferruginous-stained; small lumps of gray sandy clay
10	19.6	0.1		Rock
11	22.1	2.5	S-1	Clay, sandy, micaceous; gravely rock, gray, mixed with yellow ferruginous-stained sand
12	23.6	1.5	S-2	Sand, very fine micaceous yellow ferruginous-stained; very fine gravely rock; very small lumps of gray sandy clay
13	27.1	3.5	S-3	Silt, semi-plastic clayey, micaceous gray; with yellow ferruginous-stained lumps of small gravely rock
14	30.1	3.0	S-4	Silt, semi-plastic micaceous gray, with yellow ferruginous-stained spots; slightly contaminated
15	33.4	3.3	C-4	Clay, plastic tough silty, micaceous, dark-gray, lignitic-stained; contaminated
16	35.3	1.9	S-5	Silt, semi-plastic clayey, micaceous gray; fine rock; contaminated
17	39.5	4.2	C-5	Clay, plastic, tough silty, micaceous gray; small pebbles of white sand at 36.8 feet; contaminated
	39.5	39.5	5	Total

Remarks: At 39.5 feet still in clay.

LABORATORY TESTS OF SAMPLES 17P1, 17P2, 27P1, 51C2, 58C1, 61P1, 61P2, 72C1, 75P1, 87C1, 87C2, 92C1, 92C2, 101P1, 153P1, 154C1, 154C2-3

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Sample No.	Water of plasticity in percent	Time of slaking in minutes	Drying shrinkage		Modulus of rupture in pounds per square inch	Texture	Color
			Volume in percent	Linear in percent			
17P1	28.84	2 hrs. +	27.20	10.04	487	Fine	Greyish cream
17P2	24.25	68.5	21.50	7.75	351	Open	Lt. grey
27P1	26.65	2 hrs. +	19.30	6.90	178	Open	Lt. neutral grey
51C1	34.07	2 hrs. +	28.00	10.37	230	Fine	Greyish cream
58C1	29.32	30.0	23.30	8.46	216	Fine	Greyish cream
61P1	25.23	34.0	17.90	6.36	157	Fine	Neutral grey
61P2	32.86	41.0	27.30	10.08	260	Fine	Neutral grey
72C1	30.41	72.0	21.30	7.67	206	Fine	Lt. grey
75P1	30.83	82.5	27.30	10.08	369	Fine	Medium grey
87C1	24.80	25.0	17.90	6.36	204	Open	Lt. grey
87C2	25.58	20.0	16.20	5.72	224	Open	Lt. greyish buff
92C1	36.51	60.0	30.80	11.55	294	Fine	Medium grey
92C2	42.66	45.0	35.90	13.78	178	Fine	Brownish grey
101P1	30.52	21.0	21.20	7.63	251	Fine	Greyish pink
153P1	42.32	2 hrs. +	33.80	12.85	256	Fine	Lt. grey
154C1	41.32	13.5	30.10	11.25	172	Fine	Greyish cream
154C2-3	34.44	13.0	24.40	8.90	177	Fine	Greyish yellow

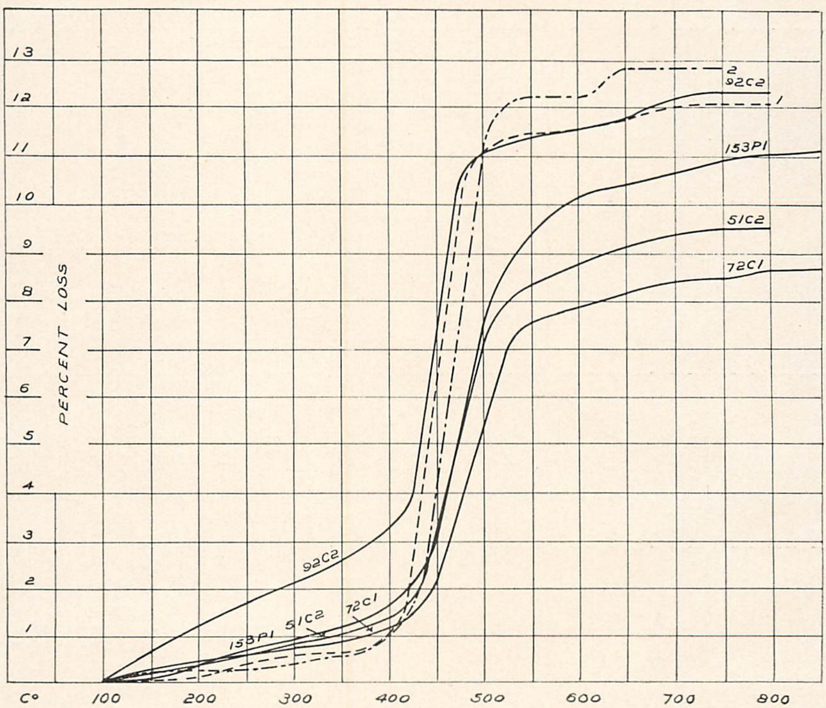

Figure 31.—Thermal dehydration curves of Winston County anauxite clays 51C2, 72C1, 92C2, and 153P1; and of typical anauxite 1 and 2

SCREEN ANALYSES

Retained on screen	Percent residue for each clay								
	17P1	17P2	51C2	72C1	75P1	101P1	153P1	154C1	154C2-3
20									
30	.12	.00	.19	.15	.02	.88	.11	.50	1.81
60	.19	.01	.73	.17	.20	1.41	.16	.64	2.10
100	.46	.73	1.03	.26	.17	.84	.18	.93	3.99
150	.36	2.78	.35	.34	.09	.79	.30	1.11	3.45
200	.77	4.60	.67	.84	.30	1.63	.29	1.14	3.48
250	.60	1.48	.32	.49	.07	.03	.11	.34	1.00
Cloth	97.50	90.40	96.71	97.75	99.15	94.42	98.85	95.34	84.17

Character of residue

Abundance: quartz 51C2; micaceous limonitic clay 72C1, 154C1, 154C2-3; gypsum 75P1; plant fragments 75P1, 101P1; ferruginous sandstone 17P1; clay ironstones 101P1. Considerable quantity: limonite 51C2; quartz 72C1; clay 75P1. Small amount: hematite 51C2, 101P1, 154C1; plant fragments 17P1, 51C2; magnesite (?) 72C1; limonitic clay lumps 17P1; quartz 101P1, 154C2-3; pyrite 101P1; ferruginous material 154C2-3. Trace of limonite 75P1.

Abundance: quartz 51C2, 153P1, 154C1; limonitic clay 51C2, 154C1; clay ironstones 101P1; clay nodules 153P1, 154C2-3; micaceous limonitic clay 72C1. Considerable quantity: plant fragments 72C1; ferruginous sandstone 17P1; clay, gypsum 75P1. Small amount: hematite 72C1, 101P1; quartz 101P1, 154C2-3; ferruginous material 51C2, 154C1, 154C2-3. Carbonaceous material 51C2, 17P1; plant fragments 17P1, 75P1, 153P1; limonite 75P1; grey clay 154C2-3; marcasite, siderite 154C1. Trace of limonite, magnetite 153P1.

Abundance: quartz 51C2, 72C1, 153P1, 154C1, 17P1, 17P2; limonite 17P1; ferruginous sandstone, plant fragments, muscovite 17P2; gypsum 75P1; clay ironstones 101P1; clay 153P1, 154C2-3. Considerable quantity: limonitic clay 75P1; sandstone, ferruginous material, plant fragments 17P1. Small amount: lignite 17P2, 75P1; grey clay 17P2, 51C2, 72C1, 75P1, 101P1, 154C1, 154C2-3; ferruginous material 51C2, 154C1, 154C2-3; quartz 75P1, 101P1, 154C2-3; limonitic clay 51C2; micaceous limonitic clay 101P1; carbonaceous material 51C2. Trace: muscovite 17P1; carbonaceous material 72C1.

Abundance: quartz 17P1, 17P2, 51C2, 72C1, 101P1, 153P1, 154C1, 154C2-3; limonite 17P1; limonitic clay 51C2, 75P1, 154C1; muscovite 17P2; clay, gypsum 75P1; iron carbonate 101P1; ferruginous sandstone 17P2. Considerable quantity: rutile, ferruginous material 17P1; hematite, limonitic clay 72C1; clay 154C2-3. Small amount: plant fragments 17P2, 72C1, 154C1; hematite 51C2, 101P1; carbonaceous material 51C2, 101P1; quartz 75P1; lignitic material 75P1; clay 101P1, 153P1, 154C1; ferruginous sand 75P1; muscovite 154C2-3. Trace: muscovite 17P1, 51C2, 72C1, 154C1; pyrite 101P1; hematite 154C1.

Abundance: quartz 17P1, 51C2, 101P1, 153P1, 154C1, 154C2-3; limonite 17P1; limonitic clay 51C2, 75P1, 101P1; muscovite 72C1; hematite 101P1; clay 154C2-3. Considerable quantity: quartz 17P2; clay 153P1; muscovite 154C2-3. Small amount: muscovite 17P1, 51C2, 101P1; rutile 17P1, 17P2, 101P1; hematite 51C2, 72C1; carbonaceous material 51C2; plant fragments 72C1; limonitic clay 72C1, 154C1; clay 72C1, 75P1, 101P1, 154C1; biotite 72C1; gypsum 75P1; lignitic material 75P1; ferruginous sand 17P2; lignite, pyrite 153P1. Trace: magnetite 75P1; muscovite, hematite 154C1; kaolin 154C2-3.

Abundance: quartz 17P1, 17P2, 51C2, 72C1, 101P1, 153P1, 154C1, 154C2-3; limonite 17P1; muscovite 17P2, 72C1, 154C2-3; limonitic clay 51C2; limonitic material 75P1; microcline 154C2-3. Considerable quantity of clay 153P1. Small amount: muscovite 17P1, 51C2, 154C1; rutile 17P1; ilmenite 51C2; carbonaceous material 51C2; hematite 72C1, 101P1; biotite 72C1; limonitic clay 72C1, 154C2-3; gypsum 75P1; iron carbonate, kaolin 101P1; feldspar, clay 154C1. Trace: rutile 17P2, 153P1, 154C1, 154C2-3; lignitic material 75P1, 154C1; biotite 101P1; tourmaline 154C1; ferruginous rock 17P2; muscovite 75P1.

Abundance: quartz 17P1, 17P2, 51C2, 72C1, 101P1, 153P1, 154C1, 154C2-3; limonite 17P1; muscovite 17P2, 51C2, 72C1; limonitic material 75P1; microcline 154C2-3. Considerable quantity of quartz 75P1. Small amount: muscovite 17P1, 154C1, 154C2-3; rutile 17P1; ilmenite 51C2; biotite 72C1; clay 51C2, 75P1, 153P1, 154C1; limonitic clay 101P1, 154C1, 154C2-3; ferruginous material 75P1; kaolin 101P1; feldspar 154C1. Trace: rutile 17P2, 101P1, 154C1, 154C2-3; clay, hematite 72C1; lignite 101P1; tourmaline 154C1.

Clay substance with residue from above.

SCREEN ANALYSES

Retained on screen	Percent residue for each clay 27P1	58C1	61P1	61P2	87C1	87C2	92C1	92C2
20								
30	.10	.58	.46	.62	.11	.06	.01	.07
60	.33	1.27	1.30	1.32	.16	.15	.03	.08
100	6.85	.83	2.86	2.72	.28	.31	.36	.12
150	3.74	1.00	4.37	3.32	.60	.34	.30	.13
200	4.32	1.75	6.34	3.93	2.02	.57	.07	.12
250	2.24	1.42	5.25	1.77	2.55	.49	.00	.09
Cloth	82.42	93.15	79.42	86.32	94.28	98.08	98.23	99.39

Note: Screen analyses were determined only on material passing 20-mesh screen

SCREEN ANALYSES

Character of residue
Abundance: quartz 27P1; limonite 58C1; lignitic clay nodules 61P1; clay ironstones 61P2; hematite 87C1; earthy gypsum and salt 87C2. Considerable quantity: hematite 58C1; micaceous lignitic clay nodules 61P1; limonitic clay nodules 87C1; limonite 87C2. Small amount: plant fragments 27P1, 61P1; ferruginous rock, carbonaceous material 27P1; muscovite 61P1; quartz, clay nodules, pyrite 61P2.
Abundance: quartz 27P1, 58C1, 61P2; limonite 58C1; lignitic clay nodules 61P1; clay ironstones 61P2; plant fragments 87C1. Considerable quantity: hematite 58C1; plant fragments 87C2; grey clay, earthy hematite 92C2. Small amount: limonite 27P1, 87C2; plant fragments 27P1, 92C1; limonitic clay nodules 61P1; lignitic material 61P2; quartz 61P1, 87C1, 92C1; micaceous limonitic clay 87C1, 87C2; lignitic clay 92C1.
Abundance: quartz 27P1, 58C1, 61P1, 61P2, 87C2; hematite 58C1; clay ironstones 61P2; micaceous limonitic clay, plant fragments, sand 87C1; limonite 87C2. Considerable quantity: plant fragments 92C1; hematite 92C2. Small amount: ferruginous rock 27P1; limonite 27P1, 92C1; plant fragments 58C1; muscovite 61P1; lignitic clay nodules 61P1; clay nodules 61P2, 92C2, 87C1; carbonaceous material 87C1; lignite 92C2; quartz 92C1, 92C2. Trace: rutile 87C1; biotite, hematite 87C2.
Abundance: quartz 27P1, 58C1, 61P1, 61P2, 87C1, 87C2; limonite 58C1; muscovite 61P1, 87C1, 87C2. Considerable quantity: quartz 92C1, 92C2; plant fragments 92C1; hematite, carbonaceous material 92C2. Small amount: ferruginous rock 27P1; limonite 27P1, 92C1; muscovite 58C1; carbonaceous material 58C1; hematite 58C1; clay nodules 61P1, 61P2, 87C1, 92C1; plant fragments 87C1, 87C2; lignite 61P1; clay ironstones 61P2; grey clay, limonitic clay 92C2. Trace: rutile 61P2, 87C1; tourmaline 61P2; kaolin 92C2.
Abundance: quartz 27P1, 58C1, 61P1, 87C2, 92C1, 92C2; muscovite 27P1, 61P1, 87C1, 87C2; clay 92C1; lignite, hematite 92C2. Considerable quantity: limonite 87C2; ferruginous material 92C1. Small amount: hematite, limonite, muscovite 58C1; clay nodules 61P1, 61P2, 87C2, 92C2; lignite 61P1; muscovite, rutile 61P2; kaolin 61P2, 92C2; quartz 87C1. Trace: limonite 27P1; rutile 58C1, 61P1, 61P2; hornblend 61P1; tourmaline 61P2; biotite 87C1; lignite 92C1.
Abundance: quartz 27P1, 58C1, 61P1, 61P2, 87C2, 92C1; muscovite 27P1, 58C1, 61P1, 87C1, 87C2; clay 92C1. Considerable quantity: limonite, carbonaceous material 58C1; ferruginous material 92C1; quartz, hematite, limonitic clay, grey clay 92C2. Small amount: clay nodules 61P1, 61P2, 87C2; lignite 61P1; muscovite, feldspar 61P2; quartz 87C1. Trace: rutile 58C1, 61P1, 61P2; hornblend 61P1; tourmaline 61P2; kaolin 87C1; lignite 92C1; gypsum 92C2.
Abundance: quartz 27P1, 61P1, 61P2; muscovite 27P1, 58C1, 61P1, 61P2, 87C1, 87C2. Considerable quantity: quartz 87C1, 92C2. Small amount: quartz 58C1, 87C2, 92C2; clay nodules 61P1, 87C2; lignite 67P1, 92C2; rutile 61P2; biotite 87C2; hematite 92C2. Trace: limonite 27P1; rutile 58C1, 61P1; hematite 58C1; hornblend 61P1; clay 61P2; kaolin, biotite 87C1; gypsum 92C2.
Clay substance with residue from above.

CHEMICAL ANALYSES

Sample No.	17P1	17P2	27P1	51C2	58C1	61P1	61P2	72C1	75P1	87C1	87C2	92C1	92C2	101P1	153P1	154C1	154C2-3
Ignition loss	7.44	7.03	7.03	9.40	7.66	5.98	9.21	8.71	10.49	5.88	7.20	9.46	12.55	9.68	11.60	10.41	9.80
Silica—SiO_2	63.48	64.06	67.12	56.37	61.02	68.20	57.84	59.17	53.79	67.54	62.61	53.52	46.76	55.18	51.11	53.41	52.99
Alumina—Al_2O_3	23.59	22.07	21.23	28.61	26.06	21.71	28.05	27.66	27.49	19.86	26.78	31.96	36.31	27.41	31.61	32.70	29.03
Iron oxide—Fe_2O_3	2.16	2.58	2.38	1.66	0.81	1.49	1.57	0.23	2.36	1.43	0.46	2.19	2.16	4.31	1.44	0.79	2.82
Titania—TiO_2	1.45	1.30	1.10	1.35	1.20	0.95	1.25	1.35	1.25	1.15	1.20	1.60	1.10	1.55	1.14	1.20	1.15
Lime—CaO	0.36	0.45	0.43	1.54	0.73	0.21	0.52	0.66	1.07	1.35	0.46	0.51	0.79	1.05	0.30	1.02	1.02
Magnesia—MgO	0.34	0.90	0.70	0.87	0.45	0.70	0.08	0.80	0.72	0.49	0.99	0.65	1.11	0.27	1.89	0.63	0.27
Potash—K_2O	0.03	0.22	0.01	0.09	0.08	None	None	0.04	0.05	0.06	0.25	0.55	0.07	0.56	0.20	0.05	0.05
Soda—Na_2O	0.44	0.90	0.07	0.11	0.43	0.46	0.44	0.04	0.46	0.08	0.21	0.13	0.30	0.86	1.52	0.01	0.32
Sulfur—SO_3	0.47	0.62	0.03	0.23	0.13	Trace	Trace	0.10	1.46	1.37	0.30	0.14	0.18	Trace	0.58	0.51	0.78
Totals based on dry weight—110°C	99.76	100.13	100.10	100.23	98.57	99.70	98.96	98.76	99.14	99.21	100.46	100.71	101.33	100.87	101.39	100.73	98.23
Moisture—110°C	3.12	2.52	2.50	2.10	0.64	2.11	1.43	1.24	2.96	0.56	0.63	2.06	1.23	3.16	2.17	1.14	2.28
Soluble salts—SO_4	0.15	0.10	0.20	0.30	0.20	0.10	0.40	0.10	0.90	0.15	0.30	0.55	0.30	0.20	0.65	0.15	0.15

SOLUBLE AND INSOLUBLE VALUATION

Sample No.*	51C2	58C1	61P2	72C1	92C2	101P1	153P1
Insoluble	65.00	71.06	62.64	72.41	67.27	67.31	62.04
Soluble—Fe_2O_3	0.36	0.08	0.68	0.55	0.87	1.44	1.04
Soluble—Al_2O_3	23.44	21.33	22.95	20.02	16.24	17.68	18.21

*Samples used for soluble and insoluble valuation and thermal dehydration data were washed through 250 mesh screen.

THERMAL DEHYDRATION

Temp.C°	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850
51C2	0.00	0.15	0.30	0.55	0.80	1.05	1.45	3.20	7.08	8.35	8.80	9.10	9.35	9.50	9.50	
58C1	0.00	0.30	0.50	0.65	0.85	1.10	1.30	3.30	6.50	7.30	7.70	8.05	8.20	8.20		
61P2	0.00	0.35	0.55	0.75	1.05	1.40	1.65	3.20	7.70	9.00	9.40	9.65	10.00	10.00		
72C1	0.10	0.35	0.55	0.70	0.85	1.03	1.25	2.25	6.35	7.68	7.98	8.25	8.50	8.60	8.70	8.70
92C2	0.20	0.80	1.35	1.93	2.30	2.75	3.48	7.35	11.25	11.52	11.80	12.08	12.32	12.47	12.47	
101P1	0.15	0.40	0.70	0.90	1.15	1.45	1.80	3.90	7.60	8.40	8.75	9.05	9.25	9.40	9.50	9.50
153P1	0.00	0.08	0.38	0.65	0.93	1.20	1.70	3.08	7.43	9.73	10.20	10.45	10.68	10.93	11.05	11.13

Pyro-physical properties

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
17P1	04	27.90	15.63	1.79	2.48	3.66	1.25	2254	Pinkish cream
	02	24.40	13.20	1.82	2.45	4.95	1.70	2864	Cream
	1	23.27	12.34	1.89	2.45	6.78	2.32	3562	Lt. orange
	3	19.40	9.88	1.96	2.44	7.85	2.71	4083	Orange
	5	16.21	7.76	1.99	2.36	10.79	3.74	4303	Orange
	7	11.76	5.77	2.07	2.32	11.06	3.85	5013	Orange buff
	9	10.33	5.25	2.08	2.21	17.32	6.17	5151	Lt. greyish buff
	11	6.17	2.92	2.12	2.26	19.20	6.86	5335	Olive grey
	13	4.22	1.92	2.20	2.29	22.40	8.11	5281	Olive grey
	13½	9.33	4.98	1.87	2.06	9.00	3.09	N. D.	Dark olive grey
	15	16.90	10.31	1.63	1.97	–2.29	–.77	3076	Dark olive grey
17P2	04	25.90	14.13	1.83	2.46	5.10	1.73	1475	Lt. pink
	02	22.80	12.15	1.89	2.40	8.01	2.74	2064	Cream
	1	21.00	11.10	1.89	2.40	8.30	2.85	2408	Cream
	3	17.60	8.90	1.93	2.37	8.45	2.90	2755	Cream
	5	15.70	7.88	1.96	2.36	11.73	4.06	2988	Lt. buff
	7	14.50	7.30	1.98	2.33	12.03	4.24	3017	Lt. buff
	9	9.31	4.43	2.07	2.26	15.50	5.46	3499	Lt. buff
	11	9.61	4.62	2.07	2.29	15.70	5.53	3554	Greyish buff
	13	7.14	3.37	2.12	2.27	16.97	6.04	3518	Bluish grey
	13½	4.55	2.10	2.16	2.25	20.01	7.17	N. D.	Bluish grey
	15	11.37	6.12	1.85	2.09	10.70	3.70	2866	Bluish grey
27P1	04	29.80	17.23	1.72	2.53	2.05	.70	1415	Cream
	02	29.60	16.80	1.77	2.53	3.79	1.28	1573	Cream
	1	29.30	15.19	1.77	2.50	7.71	2.67	1936	Cream
	3	26.71	14.61	1.84	2.48	8.03	2.78	2550	Cream
	5	22.80	11.33	1.92	2.46	12.20	4.24	2675	Cream
	7	20.80	10.74	1.98	2.45	14.30	5.01	2765	Cream
	9	15.50	7.77	2.00	2.36	16.12	5.72	2850	Cream
	11	13.15	6.91	2.03	2.33	17.41	6.21	2969	Greyish cream
	13	10.33	5.05	2.04	2.28	17.51	6.25	3211	Greyish cream
	13½	8.36	4.01	2.08	2.27	19.10	6.82	N. D.	Mottled grey
	15	9.01	4.04	1.95	2.34	18.20	6.50	3763	Mottled grey
	20	20.15	12.19	1.65	2.07	15.70	5.52	1843	Bluish grey

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
51C2	04	33.58	19.53	1.71	2.58	8.15	2.81	1983	Pink
	02	29.15	13.19	1.77	2.56	11.95	4.17	2036	Lt. cream
	1	21.80	9.60	1.86	2.52	17.21	6.14	N. D.	Lt. cream
	3	16.75	7.75	2.14	2.52	25.42	9.35	2265	Cream
	5	14.55	6.61	2.19	2.50	27.90	10.33	3311	Cream
	7	11.82	5.48	2.22	2.47	29.25	10.91	4319	Lt. buff
	9	8.00	3.37	2.28	2.45	30.65	11.51	4788	Lt. grey
	11	3.55	1.52	2.32	2.41	30.05	11.25	N. D.	Medium grey
	13	2.18	.97	2.24	2.29	31.40	11.81	N. D.	Grey
	13½	2.34	1.05	2.21	2.27	29.00	10.79	N. D.	Slate grey
	15	9.08	4.49	2.02	2.22	21.80	7.87	N. D.	Brownish grey
58C1	04	31.50	18.58	1.69	2.60	3.64	1.25	1306	Pink
	02	25.90	14.07	1.85	2.48	11.86	4.14	1928	Cream
	1	25.80	14.50	1.84	2.51	11.76	4.10	2084	Cream
	3	20.68	10.77	1.92	2.42	17.04	6.06	2634	Cream
	5	16.60	8.24	2.01	2.42	19.30	6.90	2944	Cream
	7	16.11	8.46	2.01	2.42	19.10	6.81	2978	Lt. buff
	9	9.22	4.35	2.03	2.22	21.25	7.69	N. D.	Lt. grey buff
	11	8.38	4.10	2.12	2.33	23.60	8.58	N. D.	Olive grey
	13	4.97	2.36	2.10	2.21	24.38	8.90	3478	Olive grey
	13½	4.07	1.86	2.18	2.28	25.73	9.47	N. D.	Olive grey
	15	10.47	5.69	1.84	2.06	11.73	4.10	2485	Olive grey
61P1	04	31.26	18.38	1.69	2.47	-4.07	-1.39	724	Lt. cream
	02	31.56	17.93	1.75	2.56	-.69	-.24	999	Lt. cream
	1	30.83	17.76	1.73	2.51	3.66	1.25	1370	Lt. cream
	3	30.14	16.86	1.78	2.56	4.72	1.63	1455	Cream
	5	26.35	13.81	1.90	2.59	10.14	3.52	1604	Cream
	7	21.33	11.26	1.89	2.41	10.26	3.56	1636	Cream
	9	20.60	10.67	1.93	2.42	10.93	3.81	2244	Cream
	11	15.66	7.75	2.01	2.39	13.82	4.87	2104	Cream
	13	13.43	6.63	2.02	2.34	16.26	5.76	2226	Greyish cream
	13½	8.48	4.05	2.09	2.29	17.45	6.21	N. D.	Grey
	15	5.21	2.52	2.07	2.19	19.27	6.90	2794	Grey
	20	26.52	17.64	1.50	2.04	-15.27	-5.38	Bloated	Grey

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
61P2	04	32.45	19.41	1.67	2.47	5.36	1.83	1539	Cream
	02	28.00	16.89	1.69	2.36	7.24	2.50	1694	Cream
	1	26.90	14.56	1.84	2.52	12.62	4.43	2835	Cream
	3	20.80	10.34	1.98	2.49	19.29	6.90	3073	Cream
	5	17.25	8.79	2.07	2.47	20.68	7.44	3199	Lt. buff
	7	15.85	7.71	2.11	2.44	24.41	8.94	3220	Lt. buff
	9	11.78	5.44	2.17	2.46	27.30	10.08	4145	Lt. buff
	11	10.65	5.00	2.13	2.38	26.10	9.59	4068	Lt. grey-buff
	13	8.23	3.86	2.13	2.32	26.90	9.92	4323	Lt. grey-buff
	13½	5.48	2.49	2.17	2.30	27.30	10.08	N. D.	Grey, specked
	15	6.30	2.93	2.14	2.28	25.80	9.47	4476	Grey, specked
	20	19.82	9.68	1.84	2.24	12.54	4.39	2061	Greyish brown
72C1	04	31.23	18.34	1.70	2.48	4.04	1.39	2150	Pink
	02	29.90	17.70	1.71	2.45	8.49	2.92	2602	Cream
	1	27.04	14.59	1.85	2.52	12.01	4.21	2754	Cream
	3	21.25	10.61	1.99	2.51	18.41	6.59	3430	Cream
	5	14.34	6.83	2.10	2.44	21.45	7.75	3713	Cream
	7	13.63	6.46	2.08	2.45	22.22	8.07	3955	Cream
	9	8.30	3.84	2.17	2.36	23.90	8.70	4302	Lt. grey buff
	11	8.74	4.07	2.12	2.33	23.78	8.66	4739	Lt. grey
	13	4.97	2.25	2.20	2.31	26.28	9.67	5313	Lt. grey
	13½	3.53	1.56	2.27	2.34	28.43	10.58	N. D.	Slate grey
	15	9.62	5.12	1.88	2.08	13.36	4.64	5902	Slate grey
75P1	04	26.81	15.30	1.78	2.44	9.46	3.27	2583	Pink
	02	20.50	10.13	2.02	2.47	19.78	7.09	3072	Cream
	1	18.70	10.22	2.01	2.44	21.90	7.91	4228	Cream
	3	11.47	5.30	2.17	2.45	26.20	9.63	3846	Buff
	5	3.46	1.55	2.22	2.30	27.98	10.37	1024	Grey buff
	7	8.89	4.25	2.10	2.31	24.34	8.90	7575	Lt. grey
	9	5.52	2.77	2.13	2.27	24.69	9.02	5155	Olive drab
	11	5.52	2.85	1.92	2.03	16.26	5.76	5538	Olive drab
	13	4.47	3.58	1.99	2.14	19.19	6.86	5679	Grey, specked
	15	15.37	9.85	1.56	1.85	−3.17	−1.08	2946	Grey, specked

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
87C1	04	30.03	17.30	1.73	2.47	-.49	-.17	1064	Lt. cream
	02	29.28	16.23	1.80	2.55	3.60	1.21	1218	Lt. cream
	1	27.78	15.37	1.81	2.50	3.98	1.35	1552	Lt. cream
	3	25.00	13.89	1.80	2.40	5.75	1.97	1970	Cream
	5	23.59	12.08	1.96	2.56	6.63	2.29	2027	Cream
	7	21.80	11.64	1.87	2.39	10.54	3.67	2050	Cream
	9	17.99	9.09	1.98	2.41	11.51	4.03	N. D.	Cream
	11	10.37	4.82	2.07	2.31	14.32	5.05	3223	Lt. grey
	13	5.79	2.65	2.17	2.31	19.59	7.01	2888	Grey
	13½	4.30	2.01	2.14	2.24	19.82	7.13	N. D.	Grey
	15	14.32	8.18	1.75	2.04	3.28	1.11	2581	Grey
87C2	04	30.83	17.80	1.74	2.52	1.79	.60	1439	Lt. cream
	02	28.11	15.78	1.80	2.51	6.09	2.08	N. D.	Lt. cream
	1	26.91	14.76	1.82	2.48	6.46	2.22	2906	Lt. cream
	3	22.37	11.88	1.88	2.42	10.68	3.70	3327	Lt. cream
	5	19.23	9.72	1.97	2.44	12.21	4.28	3848	Cream
	7	18.12	9.04	2.02	2.45	15.31	5.42	N. D.	Cream
	9	9.19	4.31	2.13	2.34	22.36	8.11	N. D.	Cream
	11	4.94	2.24	2.20	2.32	23.41	8.54	N. D.	Lt. grey
	13	.25	.11	2.23	2.24	24.88	9.10	5547	Lt. grey
	13½	1.29	.63	2.08	2.11	18.05	6.44	N. D.	Lt. grey
	15	13.74	7.75	1.77	2.05	4.94	1.70	2460	Lt. grey
92C1	04	33.03	19.59	1.68	2.51	7.05	2.42	3096	Pink
	02	26.70	14.30	1.87	2.55	16.50	5.83	3190	Cream
	1	25.95	13.80	1.88	2.54	15.49	5.46	4691	Lt. cream
	3	18.91	9.99	2.05	2.60	24.63	9.02	5720	Cream
	5	6.29	3.12	2.20	2.37	28.60	10.62	5652	Lt. buff
	7	6.23	2.84	2.20	2.38	30.71	11.55	5000	Lt. buff
	9	6.38	3.27	1.90	2.08	20.45	7.36	5674	Lt. grey
	11	6.44	3.23	2.03	2.16	24.68	9.02	5161	Medium grey
	13	1.60	.71	2.25	2.29	32.05	12.11	N. D.	Medium grey
	13½	2.47	1.24	1.97	2.03	23.40	8.50	N. D.	Medium grey
	15	5.66	3.10	1.82	1.86	10.64	3.70	3497	Medium grey

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
92C2	04	31.07	17.62	1.69	2.41	15.65	5.53	N. D.	Pink
	02	30.20	16.97	1.70	2.43	17.90	6.36	N. D.	Cream
	1	19.77	9.86	1.82	2.50	26.35	9.71	N. D.	Cream
	3	12.11	5.66	2.01	2.53	34.67	13.24	N. D.	Lt. grey
	5	5.49	2.49	2.13	2.43	40.10	15.70	N. D.	Grey
	7	3.02	1.32	2.29	2.33	41.91	16.60	N. D.	Grey
	9	1.24	.51	2.53	2.56	43.92	17.57	N. D.	Grey
	11	2.06	1.30	2.43	2.46	35.36	13.55	N. D.	Grey
101P1	04	29.15	16.83	1.72	2.39	7.46	2.57	1430	Pink
	02	24.90	13.31	1.88	2.50	16.39	5.80	1588	Cream
	1	24.33	12.95	1.91	2.54	17.42	6.21	1875	Cream
	3	18.46	9.03	2.04	2.51	21.31	7.71	2490	Buff
	5	16.64	8.08	2.10	2.48	22.26	8.18	3086	Buff
	7	15.05	7.26	2.07	2.44	25.95	9.55	3705	Buff
	9	8.58	3.88	2.17	2.37	26.26	9.67	4116	Buff
	11	8.04	3.70	2.18	2.37	26.46	9.75	4175	Grey-buff
	13	6.51	3.09	2.10	2.25	26.20	9.66	4579	Brownish grey
	13½	5.04	2.26	2.23	2.35	28.66	10.66	N. D.	Brownish grey, iron pits
	15	10.15	5.09	2.00	2.23	21.38	7.71	3043	Brownish grey, iron pits
	20	15.98	9.62	1.66	1.93	2.44	.84	1696	Mottled brown, iron pits
153P1	04	35.00	21.60	1.62	2.48	10.44	3.63	898	Cream
	02	32.55	18.28	1.77	2.63	17.91	6.40	1020	Cream
	1	26.38	13.81	1.92	2.59	26.36	9.71	1470	Cream
	3	20.31	9.82	2.07	2.59	31.05	11.68	1669	Cream
	5	13.50	6.47	2.09	2.41	31.80	11.92	2945	Cream
	7	11.22	5.19	2.25	2.55	37.31	14.46	N. D.	Cream
	9	2.60	1.08	2.41	2.48	41.30	16.27	3630	Lt. grey
	11	2.28	.94	2.40	2.47	38.55	15.01	4316	Lt. grey
	13	3.17	1.63	2.15	2.17	33.58	12.76	4120	Lt. grey
	13½	2.90	1.29	2.26	2.33	36.65	14.14	N. D.	Grey
	15	2.26	1.00	2.31	2.36	37.13	14.36	4480	Grey
	20	10.30	5.65	1.82	2.03	20.18	7.25	1424	Grey

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
154C1	04	38.56	24.60	1.56	2.55	7.93	2.74	1089	Pink
	02	35.13	20.45	1.72	2.65	14.88	4.24	N. D.	Pink
	1	34.01	17.96	1.71	2.47	16.06	5.68	2445	Lt. cream
	3	26.67	14.26	1.88	2.56	24.75	9.06	3175	Lt. cream
	5	15.90	7.28	2.18	2.59	33.65	12.80	N. D.	Cream
	7	9.08	3.94	2.20	2.42	34.63	13.24	N. D.	Cream
	9	7.80	3.48	2.26	2.45	34.62	13.24	4800	Lt. grey
	11	5.76	2.64	2.16	2.32	35.70	13.69	5030	Lt. grey
	13	5.53	2.60	2.13	2.25	34.80	13.29	5065	Blue-grey
	13½	3.66	1.63	2.23	2.32	36.36	14.00	N. D.	Blue-grey
	15	2.01	.95	2.67	2.74	38.70	15.05	5530	Mottled grey
	20	16.99	9.62	1.77	2.13	18.70	6.67	2111	Mottled grey
154C2-3	04	39.41	24.91	1.58	2.55	5.92	2.04	1260	Pink
	02	34.28	20.12	1.70	2.60	13.40	5.42	1500	Cream
	1	33.85	19.31	1.75	2.65	14.08	4.94	2361	Cream
	3	32.76	17.03	1.92	2.58	22.00	7.95	2446	Lt. buff
	5	18.00	8.83	2.04	2.52	27.23	10.08	4337	Buff
	7	13.19	6.27	2.10	2.43	30.11	11.21	3992	Buff
	9	13.10	6.31	2.08	2.39	30.40	11.38	4743	Buff
	11	12.05	5.72	2.10	2.39	29.15	10.87	4316	Grey-buff
	13	8.60	4.01	2.14	2.34	30.36	11.38	3997	Grey-buff
	13½	5.29	2.46	2.14	2.30	32.48	12.28	N. D.	Grey-brown
	15	7.84	3.65	2.14	2.32	30.51	11.46	3531	Mottled brown
	20	16.34	8.52	1.91	2.29	21.52	7.79	2164	Mottled brown

PYRO-PHYSICAL PROPERTIES

Sample No.	17P1	17P2	27P1	51C2	58C1	61P1	61P2	72C1	75P1
Steel hardness, cone	5	5–7	3	3	3	5	3	3	02
Burning range, cones	5–13	3–13½	3–15	3–13	3–14	5–15	3–15	3–14	1–14
Overburning, cone	13½	15	15	13½	15	15+	15+	–15	15
Softening point, cone	26	28	28	31–32	30	29	30	31	29

Sample No.	87C1	87C2	92C1	92C2	101P1	153P1	154C1	154C2-3
Steel hardness, cone	9	5	02	04	3	3	3	3
Burning range, cones	5–14	5–13½	1–14	1–11	5–15	5–20	5–15	5–14
Overburning, cone	15	15	13½+	11+	15	20	20	15+
Softening point, cone	28	29–30	32	32	28	31–32	32	30–31

SUMMARY OF RESULTS

Clays represented by samples numbered 17P1, 17P2, 27P1, 51C2, 58C1, 61P1, 61P2, 72C1, 75P1, 87C1, 87C2, 92C1, 92C2, 101P1, 153P1, 154C1, and 154C2-3 have been grouped together, because they are cream to buff burning. These clays are of the ball, or bond, type; they are fine-grained, plastic, colloidal, and have moderate to excellent strength in both the dried and fired state and have a wide burning range. Their plastic dry and fired properties are comparable when taking into consideration the influence of accessory minerals which vary with the individual clays.

The chemical analyses and thermal hydration curves of these clays indicate that the principal clay mineral common to the group is anauxite. Ross and Kerr,* in their study of the kaolin minerals, give four chemical analyses of anauxite. These analyses, reprinted in Table A, were based on carefully hand-picked samples which were freed from obvious impurities. The chemical analyses of clays 51C2, 75P1, 92C1, and 153P1, also given in Table A, have been recalculated to include moisture below 110°C. and to exclude excess silica present in the form of quartz, indicated by their respective screen analyses. For the purpose of comparing the chemical analyses of the Winston County clays with those of typical anauxite, it is assumed that all uncombined silica was removed by screening the samples through 250 mesh seive.

TABLE A

	Ross and Kerr *					Winston County			
Sample No.	1	2	3	4	Theoretical	75P1	51C2	153P1	92C1
SiO_2	54.32	53.80	52.46	48.80	54.30	52.06	53.70	49.50	51.60
Al_2O_3	29.96	32.48	32.20	35.18	32.91	26.90	29.00	31.30	31.90
Fe_2O_3	2.00	1.12	1.69	1.24		2.35	1.68	1.43	2.18
MgO	.14	.26	None	None		.70	.88	1.87	.64
CaO	.32	.34	.03	.22		1.05	1.56	.30	.51
K_2O	None	N. D.	.31	.40		.05	.09	.20	.55
Na_2O	.37	N. D.	.25	.25		.45	.11	1.51	.13
TiO_2	N. D.	N. D.	.55	.61		1.22	1.37	1.13	1.59
H_2O-	.84	.94	1.38	1.16		2.96	2.10	2.17	2.06
H_2O+	11.80	10.98	12.07	12.81	12.79	11.40	9.75	12.05	9.56
Totals	99.75	99.92	100.94	100.67	100.00	99.13	100.24	101.46	100.72
$SiO_2:R_2O_3$	294:100	274:100	267:100	230:100	280:100	302:100	298:100	268:100	256:100

*Ross, C. S., and Kerr, P. F., The kaolin minerals, U. S. Geological Survey Professional Paper 165, 1930.

Ross and Kerr say, that since the water in anauxite varies only slightly and inversely to silica and the silica to alumina varies widely, the only significant ratios are silica to alumina, expressed as SiO_2:R_2O_3, which includes ferric oxide with alumina. From the analyses in Table A it is evident that the SiO_2:R_2O_3 ratios of the Winston County clays are comparable to the SiO_2:R_2O_3 ratios of typical anauxite. The similarity of the Winston County clays to anauxite is corroborated by comparing their thermal dehydration curves with the curves of anauxite determined by Ross and Kerr which are reprinted in Figure 31. From the dehydration curves of the Winston County clays it will be seen that the clays loose a considerable amount of water up to 400°C. and that the loss is at a fairly uniform rate, proportional to advancing temperature. This part of the curves indicates the presence of alumina gel, which is particularly evident in the curve for clay 92C2, and which accounts for the alumina in excess of that attributed to anauxite as indicated in the chemical analyses. To confirm further this belief, a small amount of clay 92C2 was blunged in water; and, after the settling of the clay, the clear water was siphoned off and made alkaline with ammonium hydroxide which immediately formed a heavy greenish gelatinous precipitate that upon heating turned reddish and which was identified as iron and aluminum hydroxides. It also appears that at least part of the iron is present in a soluble form.

The significant point concerning the presence of anauxite as the principal mineral in this group of clays is that silica and alumina of anauxite in the ratio of 3 to 1 allows a lower and wider maturing range than that of kaolinite clays having a silica to alumina ratio of 2 to 1. The intimate combination of silica and alumina in a ratio of 3 to 1 appears to be more conducive to the beginning of the maturing range of the clays at a lower temperature than would be the case of a mixture of silica and kaolinite with a silica to alumina ratio of 3 to 1. Consequently the anauxite clays would be more desirable for use in a greater variety of clay products than the more abundant clays of the kaolinite type.

All of these clays have a plasticity suitable for throwing on a potters wheel and for jiggering. Clays 17P2, 154C2-3, 27P1, 87C1, 58C1, 61P1, 61P2, and 101P1 should be screened to remove quartz before using in pottery. This series of clays and clays 72C1, 75P1, and 87C2 dry readily with little to no warpage and are open burning until maturity. Clays 17P1, 51C2, 153P1, 154C1, 154C2-3, 92C1, and 92C2 tend to warp, and clays 153P1, 92C1, and 92C2 tend to crack in thick bodies;

however, in thin ware such as pottery, or when mixed with non-plastic materials, no difficulty is experienced in drying and burning.

In the table of pyro-physical properties space does not permit a proper explanation of the burning behavior of several clays. The apparent over-burning or swelling of clays 51C2, 72C1, 75P1, 92C1, 92C2, 153P1, 154C1, and 154C2-3 is not accompanied by active fusion at their respective apparent overburning temperatures. The clays are undoubtedly somewhat viscous at these temperatures and become expanded by gases which are generated within the 1-inch thick test pieces and which cannot escape readily through the dense thick body. A slower burning schedule, thin ware, or the addition of non-plastic material, will lengthen the apparent burning range as was demonstrated in the utilization of these clays for refractory shapes and pottery at the laboratory of the Mississippi Geological Survey. Their softening point, or pyrometric cone equivalent, is a better index to their optimum burning temperature, than are their respective limits given in the table of pyro-physical properties.

POSSIBILITIES FOR UTILIZATION

Individual clays are suitable for use in many clay products as the sole constituent and in a still wider variety of products as a principal to minor constituent. The fine-grained plastic cream to buff burning clays are the most versatile group of Winston County and represent the most important variety. There are only a few localities in the United States where clays comparable to this group are available. Their development points to the establishment in Winston County of a clay products industry and a shipping point for finished products and raw clay.

In the following summation the more important general types of products are given rather than numerous related individual articles.

Fire brick and refractory shapes

The entire group of anauxite clays is suitable for use as a plastic clay to bond non-plastic and semi-plastic raw materials to produce the desired strength, porosity, and toughness in the finished product. The use of these clays in refractories is referred to in the section of this report dealing with the possibilities for utilization of the high alumina and high silica clays of the Betheden formation. Possibilities not heretofore enumerated include use as a high temperature cement, a binder in graphite products and abrasives. Clays 51C2, 72C1, 92C1, 153P1, 154C1, and 154C2-3 are suitable for use in No. 1 refractories. Clays 17P2, 27P1, 58C1, 61P1, 61P2, 75P1, 87C1, 87C2, and 101P1 are suitable for use in No. 2 refractories. Clay 17P1 is the least desirable but would be satisfactory for No. 3 refractories. The clays listed for No. 2 refractories would likely be suitable for use as a bond in No. 1 refractories, provided the fusion point of the finished product was equivalent to cone 31+. These clays should not be used as the sole constituent of refractory products.

Face brick

The use of Winston County bond clays as the principal constituents of high grade light-colored face brick in connection with the utilization of clays of the Betheden formation has been discussed in the two previous sections of this report. In this respect, the entire group of anauxite bond clays are suitable. The proximity of the Betheden clays and plastic bond clays makes the blending of the two materials economical.

The open burning variety of anauxite clays is suitable for light-colored face brick without the addition of any other material; they are clays 17P1 and 17P2 used together, 27P1, 58C1, 61P1, and 61P2 used separately or together, 87C1 and 87C2 used separately or together. Clay 101P1, would be improved for use in brick by the addition of Betheden clays or even sand.

The range of natural colors that can be produced in brick made from these clays will be comparable to the colors of the better grade of brick produced elsewhere. The utilization of these clays should not be overlooked by those interested in a profitable industrial development of the mineral resources of Winston County.

Enameled and salt glaze brick

The clays and combinations of clays listed above as suitable for face brick are suitable also for the production of colored-enameled brick. Pottery shapes and briquettes made from anauxite clays have been glazed with several types of enamels at the testing laboratory of the Mississippi Geological Survey and no difficulty whatsoever was experienced in the glazing and burning. Although these clays have not been tested for their ability to take a salt glaze, clays 17P1, 17P2, 27P1, 61P1, and 87C1 have the proper silica to alumina ratio for salt-glazing; and mixtures, consisting of high silica Betheden clay and any one of the clays numbered 51C2, 58C1, 61P2, 72C1, 75P1, 87C2, 101P1, would likely produce brick suitable for salt glazing. Other than brick, products such as electrical conduit, silo tile, facing and partition tile, can be made from the same brick clays and mixtures.

Stoneware

Common stone ware, formed by throwing on a potters wheel or by jiggering and coated with the bristol type of glaze, can be produced economically from clays 17P1, 51C2, 72C1, 75P1, 154C1, 58C1, 87C1, and 87C2. Clays 17P2, 61P1, 61P2, 101P1, and 154C2-3 can be made suitable by washing and screening. Clays 92C1, 92C2, and 153P1 mixed with flint or feldspar, or both, would produce a high grade stoneware comparable to chemical stoneware.

Earthenware

White and yellow earthenware are the two common types. Both are usually semi-vitreous and are composed of clay, flint, and feldspar. White earthenware, covered by a transparent glaze, comprises such products as inexpensive dinner ware and hotel china. Yellow earthenware, covered by an opaque or colored glaze, is used as kitchen ware, baking dishes, and colored dinner ware. The Winston County clays should be washed and screened before using in an earthenware body. By this process, which is not uncommon, clays 51C2, 72C1, 87C2, 153P1, and 154C1 would be suitable for use as the ball clay constituent in white earthenware. Clays 17P1, 17P2, 58C1, 61P1, 61P2, 75P1, 87C1, 92C1, 92C2, and 154C1 would be desirable for use in yellow earthenware as the principal constituent.

Art pottery

Art pottery is made from such a wide variety of clays and ceramic mixtures that almost any plastic clay that dries and burns well and is not too contaminated by quartz or ferruginous material can be made into commercial ware, the beauty of which is more dependent on design of the ware and the glaze than on the color and composition of the body. However, the better grades of art pottery are made from carefully selected raw materials and under accurately controlled manufacturing conditions.

Clays enumerated for stoneware are suitable for the inexpensive variety of art pottery. Clays and ceramic bodies suitable for white and yellow earthenware would be desirable for the better grade.

Other uses

Clays are used in ferro enamels especially for their ability to suspend non-plastic materials in the raw wet enamel, and to bond them to metal surfaces. The anauxite clays, most free from iron, quartz, soluble salts, and carbonaceous matter, particularly seem suitable. Further high silica to alumina ratio would aid rather than impair their fusion of the enamel. The clays used in enamels would likewise be suitable for use in ceramic glazes.

CLAYS OF THE PORTERS CREEK AND ACKERMAN FORMATIONS

J. NAT WOODWARD PROPERTY

TEST HOLE 18 (OLD MINE) RECORD

Location: T. 15 N., R. 12 E., Sec. 21, NW.¼, NE.¼ Drilled: Dec. 17, 1937
Elevation: Water level:

No.	Depth	Thick.	Sample	Description of strata
1	Not measured			Sand, salt and pepper-colored fine-grained slightly micaceous, argillaceous
2	4.0	4.0	P-1:C-1	Lignite, dark-brown to black fairly pure but contains a few flakes of clay throughout; blocky and coarsely jointed in lower part; at top finely jointed containing thin limonite fillings
3	16.0	12.0	P-2	Clay, dark-blue tough plastic; a very small amount of fine sand, at several levels; is almost uniform
4	16.2	0.2		Clay, slightly sandy
5	16.4	0.2		Lignite
	16.4	16.4	3	Total

Remarks: Samples of lignite taken 10 feet inside entrance of old Nat Woodward lignite mine by stripping from a scalped surface. Sample of clay taken in auger hole in drift on floor of mine at base of scalped lignite.

JOHN LOWRY OLD PLACE

TEST HOLE 20 RECORD

Location: T. 15 N., R. 12 E., Sec. 9, SW.¼, SW.¼ Completed Jan. 13, 1938
Elevation: 19.4 feet above branch Water level:

No.	Depth	Thick.	Sample	Description of strata
1	0.9	0.9		Lignite, soft (smut of 3.8 feet lignite of Hole 3)
			P-1	Clay, upper half of bed; black fine-grained at top; laminated with fine sand in middle, contains pyrite nodules; lower part obscurely laminated; not so sandy; all contains lignitic root impressions
2	8.6	7.7	P-2	Clay, lower half of bed; uniformly black and massive; fine-grained, lignitic root impressions from above; very obscurely laminated; conchoidal fracture on weathering
	9.1	0.5		Lignite
3	16.9	7.8	P-3	Clay, upper 0.9 feet brownish, seems similar in quality to that below; lower 6.9 feet gray massive fine-grained obscurely laminated; small lignitic root markings
4	18.4	1.5		Lignite
5	19.4	1.0		Clay, gray very sandy, micaceous
	19.4	19.4	3	Total

Remarks: 73 feet vertical distance from upper lignite to top of steep spur ridge.

C. J. MOREHEAD PROPERTY

Test hole 53A record

Location: T. 16 N., R. 14 E., Sec. 17, N.½, NW.¼ Drilled: May 9-13, 1938
Elevation: 30 feet above Hole 52 Water level:

No.	Depth	Thick.	Sample	Description of strata
1	2.0	2.0		Clay, soil, and subsoil, gray sticky
2	37.7	35.7	P-1	Clay, Porters Creek, very pure; some phases are slightly silty; at a depth of about 20 feet were about 5 feet of light-brown slightly sandy clay; below 25 feet, the clay is very dark-gray highly carbonaceous
	37.7	37.7	1	Total

Remarks: All cuttings from hole saved as a P-1 sample, except a C-1 sample at the base of each 5 feet of entire depth of hole.

HIGHWAY, 30 FEET SOUTHEAST CENTER LINE

Test hole 55A record

Location: T. 16 N., R. 14 E., Sec. 18, SW.¼, SW.¼ Drilled: May 3, 1938
Elevation: 205 feet above Hole 52 Water level: 8.5 feet

No.	Depth	Thick.	Sample	Description of strata
1	0.5	0.5		Soil top, dark-gray; lumps of clay and micaceous and ferruginous rock
2	34.7	34.2	P-1	Clay, micaceous silty brownish-gray to dark-gray; at 31 feet soft gray rock about 0.8 feet thick
			S-1	From 31 feet to 32 feet Rock about 0.8 feet thick; very small S-sample on account of crushed fine and mixed with clay. Clay under rock mixed as part of P-sample
	34.7	34.7	1	Total

Remarks: All cuttings from hole saved as a P-1 sample except about 0.8 feet or 0.9 feet of soft siderite between 31 feet and 32 feet.

MELVIN McCULLY PROPERTY

TEST HOLE 57 RECORD

Location: T. 15 N., R. 12 E., Sec. 15, NW.¼, SE.¼ Drilled: Feb. 14, 1938
Elevation: 76.6 feet Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	0.5	0.5		Soil top, light-brown
2	2.5	2.0	S-1	Clay, yellow plastic
3	4.0	1.5	S-2	Clay, grayish-red, iron-stained
4	8.5	4.5	P-1	Clay, brown to black silty lignitic-stained laminated; at depth of 43.5 feet one inch of hard gray iron carbonate
5	55.7	47.2	P-1	Clay, dark-gray micaceous, slightly arenaceous; lignitic, some pyrite at 8.5 feet and throughout the clay
6	59.5	3.8	S-3	Silt, fine-grained laminated steel-gray
7	75.9	16.4		Silt
	75.9	75.9	1	Total

Remarks: Hole abandoned at 75.9 feet in gray silt

LABORATORY TESTS OF SAMPLES 18P2, 20P1, 20P2, 20P3, 53AP1, 55AP1, 57P1

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Sample No.	Water of plasticity in percent	Time of slaking in minutes	Drying shrinkage		Modulus of rupture in pounds per square inch	Texture	Color
			Volume in percent	Linear in percent			
18P2	41.38	Over 2 hrs.	43.40	17.28	491	Fine	Dark brownish grey
20P1	42.84	Over 2 hrs.	45.10	18.12	578	Fine	Dark brownish grey
20P2	41.48	Over 2 hrs.	50.40	20.84	578	Fine	Dark slate grey
20P3	38.10	Over 2 hrs.	31.90	12.02	633	Fine	Medium neutral grey
53AP1	46.67	13.5	48.30	19.74	591	Fine	Medium neutral grey
55AP1	37.25	Over 2 hrs.	22.20	8.03	306	Fine	Dark neutral grey
57P1	33.05	Over 2 hrs.	25.70	9.43	621	Mealy	Brownish grey

CHEMICAL ANALYSES

Sample No.	18P2	20P1	20P2	20P3	53AP1	55AP1	57P1
Ignition loss	11.72	10.22	13.16	7.85	7.07	6.36	9.88
Silica—SiO_2	57.20	58.29	56.00	60.54	61.87	63.60	63.45
Alumina—Al_2O_3	19.76	19.98	21.05	19.62	21.12	17.81	19.14
Iron Oxide—Fe_2O_3	6.11	5.10	5.01	4.60	6.07	6.54	3.01
Titania—TiO_2	0.99	1.10	0.99	1.20	1.05	1.05	1.05
Lime—CaO	0.83	1.04	1.09	1.55	1.42	1.10	1.12
Magnesia—MgO	0.83	1.55	0.23	0.93	0.94	1.32	1.56
Potash—K_2O	0.12	0.21	0.10	1.38	0.24	1.09	0.04
Soda—Na_2O	0.65	1.13	1.30	1.72	0.93	0.97	0.04
Sulfur—SO_3	2.02	1.94	2.26	0.11	0.55	0.96	0.78
Totals based on dry weight—110°C	100.23	100.56	101.19	99.50	101.26	100.80	100.07
Moisture—110°C	7.89	8.39	9.23	6.00	6.99	5.61	2.91
Soluble salts—SO_4	0.85	1.15	0.25	0.15	0.65	0.55	0.20

SOLUBLE AND INSOLUBLE VALUATION

Sample No.*	18P2	20P2	53AP1	
Insoluble	74.84	70.32	80.03	*Samples used for soluble and insoluble valuation and thermal dehydration data were washed through 250 mesh screen.
Soluble—Al_2O_3	6.66	16.18	9.28	
Soluble—Fe_2O_3	3.08	2.04	2.58	

THERMAL DEHYDRATION

TempC°	100	150	200	250	300	350	400	450	500
18P2	0.00	0.35	1.05	2.15	3.33	4.15	5.13	6.90	8.23
20P2	0.05	0.20	0.70	1.40	2.45	3.77	5.28	7.78	9.68
53AP1	0.00	0.35	1.10	1.45	1.73	1.97	2.08	2.58	3.23

THERMAL DEHYDRATION (Continued)

TempC°	550	600	650	700	750	800	850	900
18P2	8.65	8.83	9.03	9.22	9.39	9.63	9.90	10.00
20P2	10.10	10.85	11.03	11.15	11.32			
53AP1	4.85	5.18	5.40	5.60	5.65	5.78	5.92	5.92

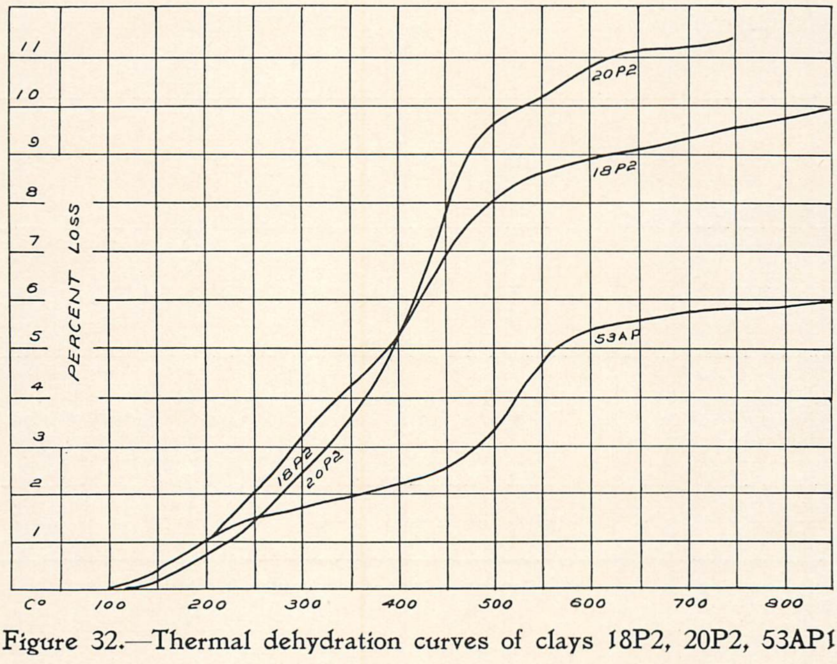

Figure 32.—Thermal dehydration curves of clays 18P2, 20P2, 53AP1

SCREEN ANALYSES

Retained on screen	Percent residue for each clay						
	18P2	20P1	20P2	20P3	53AP1	55AP1	57P1
20							
30	1.77	9.24	1.23	.29	.74	4.28	.49
60	6.92	10.63	.53	.87	1.02	3.60	.71
100	6.31	1.75	.42	.47	.97	3.44	.83
150	3.96	.44	.26	.26	.55	4.60	.58
200	7.23	2.96	.55	.34	1.69	4.77	3.14
250	1.02	1.80	.21	.25	.63	2.98	4.30
Cloth	72.79	73.18	96.80	97.50	94.33	76.33	89.95

Note: Screen analyses were determined only on material passing 20-mesh screen.

SCREEN ANALYSES

Character of residue
Abundance of micaceous lignitic clay nodules for all clays except 18P2, 20P3. Considerable quantity of marcasite 18P2. Small amount of micaceous lignitic clay nodules 18P2. Trace: limonite 20P1, 53AP1, 55AP1; ferruginous material 57P1.
Abundance of micaceous lignitic clay nodules for all clays. Considerable quantity of lignite 18P2. Small amount: ferruginous material 53AP1; plant fragments 55AP1, 57P1; pyrite 57P1.
Abundance of clay nodules for all clays. Considerable quantity of lignite 18P2. Small amount: lignite 20P2, 20P3, 57P1; quartz 20P3; ferruginous material 53AP1, 57P1; muscovite 55AP1; plant fragments 55AP1; limonite 55AP1, 57P1. Trace: quartz 53AP1; lignite 57P1.
Abundance: clay nodules for all clays; muscovite 55AP1; lignite 57P1. Considerable quantity: lignite 18P2; quartz 55AP1. Small amount: lignite 20P1, 20P2, 20P3, 53AP1; quartz 20P2, 20P3, 53AP1, 57P1; muscovite 53AP1, 57P1; magnetite 53AP1; limonite 57P1; ferruginous material 57P1. Trace: muscovite 18P2; limonite 20P1; lignite 55AP1.
Abundance: clay nodules for all clays; quartz 20P2; muscovite 55AP1; lignite 57P1. Considerable quantity: lignite 18P2, 20P1; quartz 55AP1; kaolin 57P1. Small amount: quartz 20P1, 20P3, 53AP1, 57P1; muscovite 20P1, 57P1; limonite 20P1; lignite 20P2, 20P3, 53AP1, 55AP1; pyrite 20P2; magnetite 53AP1; rutile 57P1; ferruginous material 57P1. Trace: muscovite 18P2, 53AP1; marcasite 20P1; kaolin 20P2.
Abundance: clay nodules for all clays; muscovite 20P1; quartz 20P2; lignite 20P1, 57P1; glauconite' limonite nodules 55AP1. Considerable quantity: quartz 18P2; muscovite 18P2, 57P1. Small amount: lignite 18P2, 20P2, 20P3, 53AP1; pyrite 20P2; quartz 20P3; ferruginous material 53AP1; rutile 55AP1; gypsum, kaolin 57P1.
Abundance: clay 20P1, 20P2, 53AP1, 55AP1, 57P1; quartz 18P2, 20P2, 55AP1, 57P1; muscovite 18P2, 20P1, 55AP1; lignite 20P1, 57P1. Considerable quantity: clay 18P2; limonite, glauconite, 55AP1; muscovite 57P1. Small amount: lignite 18P2, 20P2, 53AP1; limonite 20P1; pyrite 20P2; ferruginous material 53AP1; gypsum, kaolin 57P1. Trace: quartz 20P1, 53AP1; muscovite 20P2, 53AP1; rutile 20P2, 53AP1, 57P1; magnetite 53AP1.
Clay substance with residue from above.

PYRO-PHYSICAL PROPERTIES

Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
18P2	04	25.40	14.88	1.70	2.28	10.32	3.59	Cracked	Salmon
	02	21.10	11.55	1.82	2.31	14.90	5.24	Cracked	Salmon
	1	19.35	10.70	1.82	2.29	20.57	7.40	Cracked	Salmon
	3	Cracked and bloated during burning							Reddish brown
	5	Cracked and bloated during burning							Reddish brown
20P1	04	27.23	15.36	1.68	2.46	11.68	4.06	Cracked	Salmon
	02	23.01	13.72	1.69	2.21	13.84	4.87	Cracked	Light red
	1	21.62	11.96	1.81	2.18	12.57	4.39	Cracked	Dull red
	3	23.80	15.55	1.53	2.01	–8.38	–2.88	Bloated	Dull red
	5	Bloated							Reddish brown
20P2	04	24.21	14.40	1.68	2.21	10.84	3.77	Cracked	Salmon
	02	22.67	13.22	1.83	2.24	18.25	6.52	Cracked	Light red
	1	Cracked and bloated during burning							Reddish brown
	3	Cracked and bloated during burning							Reddish brown
20P3	04	27.13	19.38	1.74	2.47	18.62	6.67	Cracked	Salmon
	02	11.31	5.74	1.99	2.24	23.77	8.66	6283	Light red
	1	6.91	3.77	2.12	2.27	26.46	9.75	6740	Dull red
	3	1.22	.55	2.23	2.26	31.80	11.98	Bloated	Reddish brown
53AP1	04	16.70	9.43	1.82	2.21	14.00	4.90	Cracked	Salmon
	02	15.02	8.59	1.73	2.05	14.70	5.16	Cracked	Light red
	1	Cracked and bloated during burning							Dull red
	3	Cracked and bloated during burning							Reddish brown
55AP	04	33.38	23.13	1.56	2.35	5.65	1.94	926	Salmon
	02	26.31	15.04	1.74	2.36	7.88	2.71	2374	Salmon
	1	23.35	12.33	1.89	2.48	17.12	6.10	2445	Light red
	3	19.99	9.96	2.00	2.50	22.85	8.30	2504	Reddish brown
	5	14.27	9.38	1.52	1.77	3.97	1.35	2343	Reddish brown
57P1	04	32.10	20.15	1.59	2.35	9.90	3.42	1320	Salmon
	02	30.52	18.60	1.64	2.36	10.82	3.77	2070	Salmon
	1	27.23	15.86	1.72	2.37	17.14	6.10	2330	Light red
	3	20.84	11.05	1.89	2.38	25.25	9.27	2595	Dull red
	5	6.51	3.19	2.05	2.18	29.52	11.04	2167	Dull red
	7	Bloated							Reddish brown

Softening point P. C. E.: 18P2, cone 5; 20P1, cone 7; 20P2, cone 6; 20P3, cone 5; 53AP1, cone 5; 55AP1, cone 6; 57P1, cone 7.

SUMMARY OF RESULTS

Samples 18P2, 20P1, 20P2, and 20P3 represent clays of the Ackerman formation underlying lignite, whereas samples 53AP1 and 55AP1 are of the Porters Creek formation. Sample 57P1, a sedimentary clay, represents a silty phase of the Ackerman. These clays, though different in their geologic origin and formation, have been grouped together for study because of the similarity that exists in their physical structure, plastic and drying properties, chemical and screen analyses, and their burning characteristics. The properties that are common to the clays differ as a group from those of clays in general use, having numerical valuations relatively high or low, depending on the particular property under consideration. Detailed study of the principal minerals of the group has not been undertaken for this report; however, some observations incidental to testing are given, inasmuch as practically no published information is available concerning the fundamental characteristics of these clays individually or as a group.

The thermal dehydration curves of clays 18P2 and 20P2, chosen as typical of the Ackerman underclays, show a fairly uniform loss of water per degree rise in temperature up to 500°C, suggesting hydrated amorphous oxides of alumina or silica, or both, as the principal clay constituents and indicating the absence of hydro-aluminum silicates or other related clay minerals of definite chemical composition. According to Nutting, "a sharp shoulder in the dehydration curve is apparently the sole criterion for molecular water,"* and concerning the dehydration of the kaolin minerals, Nutting states ,"Impurities affect the shapes of these curves at temperatures below that of the sharp break (if there is one) and round off the shoulders but do not effect the temperature of the break. As little as 10 percent of the pure mineral diaspore or of a kaolinite in a mixed clay should show in a thermal analyses."†

From an air dried condition (25°C) the loss of water up to 110°C. is 7.89 percent for clay 18P2 and 9.23 percent for 20P2, which further indicates their gelatinous character affecting plastic and dry properties, and accounts for excessive shrinkage, warpage, and unusual strength in the dry state. The soluble and insoluble valuation shows 33.7 percent of the available alumina in 18P2 and 43.75 percent in 20P2 to be soluble in 18N. sulfuric acid.

The thermal dehydration curve of clay 53AP1 may be compared to that of montmorillonite; however, the steepness of the curve between

*Nutting, P.G., The Bleaching clays: U.S. Geological Survey, Cir. 3, P.40, 1933.
†Op. cit. P. 33.

450°C. and 550°C. suggests kaolin minerals as a secondary constituent. Other characteristics of this clay are comparable to those of the Ackerman underclays.

All of the clays are extremely fine-grained and have an oily or waxy plasticity conducive to lamination and other difficult working properties. Clay 57P1 is excepted, having a mealy plasticity and fairly good working properties. Drying shrinkage and warpage of the Ackerman underclays and 53AP1 of the Porters Creek are excessive. Strains developed during air drying are apparent as cracks on oven drying and burning. Clays 55AP1 and 57P1 are considerably better in this respect.

The modulus of rupture or flexual strength of the several clays in the dry state averages 544 pounds per square inch. Individual test bars ran as high as 807 pounds per square inch, the average of the highs from the group being 668 pounds per square inch. The apparent variation in strength between individual test pieces is attributed to drying strains as heretofore mentioned.

Under standard laboratory firing schedule all of the clays bloated before reaching vitrification, some swelling to twice their original size. Test pieces of clays 18P2, 20P1, 20P2, 20P3, and 53AP1 biscuited to 1700°F. in twelve hours under ideal oxidizing conditions, cracked; and on reburning to higher temperatures bloated as usual. The same treatment, applied to clays 55AP1 and 57P1, decreased cracking but did not affect their tendency to bloat. The softening point or pyrometric cone equivalent of the several clays ranged between cones five and seven.

POSSIBILITIES FOR UTILIZATION

The Ackerman and Porters Creek clays are less suitable for manufacture into structural clay products than other clays available in Winston County. In localities where desirable clays are scarce and the market price justifies the added expense, clays possessing even less desirable properties are regularly made into serviceable clay products. Of economic importance to Winston County, where there is a wide variety of clays from which to choose, is the utilization of an individual clay, for purposes for which it is best suited. It is in this light that these clays have been seriously considered.

The two outstanding characteristics of the group are, first, their exceptionally high dry strength, and second, their tendency to bloat or swell at relatively low temperatures.

High dry strength implies good bonding strength; or the ability of the clay to bond together particles of non-plastic materials. This property common to the several clays can be used to advantage in improving the dry strength of clays deficient in strength, permitting the utilization of otherwise good clays for a variety of clay products. The low sintering temperature of these clays would be advantageous in producing common clay products such as building brick and hollow tile, but would render the clays unsatisfactory for bond in refractory products such as fire brick, saggers, and crucibles.

The strength of molding sand for foundry use is usually controlled by the addition of bond clays ranging in amounts from 10 percent to 30 percent of the mass of the mold mixture. Clay decreases permeability of the bonding sand, thus limiting the amount that can be used. Clays with a sticky plasticity, while giving strength, are less desirable in a molding sand on account of the tendency of the clay-coated sand grains to adhere to the pattern and ramming tools. The Porters Creek clays and the Ackerman underclays have an oily or waxy plasticity, cohesive rather than adhesive, a desirable property of the bonding substance in molding sand. In United States patent number 2,128,404; Norman J. Dunbeck points out that as little as 5 percent of the Porters Creek clay added to clean silica sand increases strength from 75 percent to 175 percent over known mold compositions without the usual decrease in permeability when using ordinary clay. Although the fusion points of the Ackerman underclays and the Porters Creek clays from Winston County are below the pouring temperatures of molten iron and steel, the refractoriness of the molding mixture using these clays as bond should be satisfactory, due to the small percentage of clay necessary to give desired strength to the molding sand. Dunbeck claims an increase in refractoriness of 200°F. to 300°F. when using the Porters Creek clay from southern Illinois. It has been the experience of the testing laboratory of the Mississippi Geological Survey that the Porters Creek clay from different localities varies considerably in its fusion points. The effect of the Winston County clays on the refractoriness of molding sand can best be determined through commercial experimentation as laboratory methods are inapplicable.

The tendency of the clays to swell or bloat, thereby developing a vesicular structure, suggests the possibility of utilization in the manufacture of light-weight aggregate for concrete. High-grade lignite lying immediately above the Ackerman clays could be utilized in supplying fuel and probably additional porosity in the manufacture of the light-weight aggregate.

The scope of the light-weight aggregate industry is described by Hughes as follows:

"The trend in modern building construction is definitely toward the use of weight-reducing materials. The basic advantage of lighter structural weight is obvious; reduction of dead load with retention of equivalent strength affords the possibility of increasing the live load, or if this is not desirable or necessary it makes feasible a reduction in size of structural steel members and corresponding savings in other phases of construction - - - - - - .

"Burned shale aggregate now available in many sections of the country will make concrete weighing only 100 pounds per cubic foot, saving roughly 35 percent in weight and sacrificing none of the strength of a rock-sand mix. It may be more expensive, but actual experience has shown that the saving in dead load will effect a reduction in structural steel which in many instances will more than offset the increased cost of the aggregate. The vesicular nature of most light-weight aggregates gives the concrete especially good insulating, fireproofing, and soundproofing properties; yet absorption is comparatively low - - - - .

"All light-weight aggregates fall into one of three divisions, depending upon their source: (1) Those which occur naturally, such as volcanic cinder, tuff, pumice, and coal; (2) those formed as by-products in industrial processes, including cinders, slag, and sawdust; and (3) those manufactured specifically for use as concrete aggregate."

The third group includes three products made from clay; Haydite, Lytag, Cel-Seal.

"Haydite is a light-weight burned shale aggregate, developed and patented by the late Stephen J. Hayden. . . Haydite is a vesicular, clinker-like aggregate which, because of its semivitrified nature, has exceptional strength, considering its light weight and cellular structure. It is produced by burning in a rotary kiln a clay or shale, which retains its original chemical moisture content as it enters the kiln. Preheating at the charging end of the kiln vitrifies a thin layer on each particle, which prevents the gradual escape of gases during burning. Near the discharge end the material is subjected to high temperature and the resulting semifusion permits the sudden release of pent-up gases, causing each particle to expand into a porous clinker. After cooling and thorough wetting, the material is crushed and screened. One fine and two coarse sizes are produced. The average screen analysis of the sand-size Haydite is 17 per cent retained on 14 mesh, ranging to 12.5 per cent passing 100 mesh with a fineness modulus of 2.65. The coarse grade is composed of ¾ inch to 4-mesh particles and the intermediate grade of ½ inch to 4-mesh; their fineness moduli are 6.70 and 6.20, respectively. Absolute control of the process insures uniformity of the product.

"The weight of Haydite varies from 1500 to 1600 pounds per cubic yard for the sand size to about 1200 pounds for the ¾ inch - - - Haydite aggregate is especially desirable for structural concrete for all purposes where weight and strength are important factors. The average weight of Haydite concrete is only 100 pounds per cubic foot, a decided reduction from concrete made with ordinary natural aggregates. . . About one-half of the total Haydite production at the present time is used as aggregate in the manufacture of precast light-weight building units, which are highly satisfactory for all purposes where light-weight units can be utilized advantageously. . .

"Haydite is less dependent upon special raw materials than other aggregates of the light-weight group. Practically any shale or clay is satisfactory, although material containing some carbonaceous matter gives the best results. Judging from the present trend, Haydite appears to be moving toward the Atlantic seaboard markets, but the manufacturers certainly will not overlook the large potential markets of the South and Southwest, where burned shale aggregates will be free from competition of other members of the light-weight group which are excluded from those areas because of the lack of raw materials.

"Lytag is the trade name of a light-weight aggregate. . . . It is a burned shale or clay product manufactured under patents which protect the process as well as the machinery used in its manufacture. Practically every shale, clay, and even sand or loam will show vesicular structure when sintered by the Lytag process, but easily fusible common shale and clay will give a more satisfactory product at a cheaper operation cost.

"The sintering process for making Lytag is unique in the light-weight field. Shale crushed to 11-mesh fineness is mixed with a small proportion of granulated coal in a pug mill, an important feature of the process being the addition of moisture. It is then spread over suction chambers and ignited by a flame applied for only about 30 seconds. Combustion without flame continues downward, aided by down draft. The combustion process may be likened to smoking a pipe, a match lights it, suction keeps it ignited, and the ashes correspond to the sinter that remains in the grate. The machine employed apparently corresponds, at least in principle, to the Dwight-Lloyd sintering machine extensively used for roasting and calcining ore.

"The properties of the sinter are more dependent upon the process itself than upon the raw shale. The operator may vary the shale-coal ratio or the moisture content, he may change the speed or revolution or the depth of the charge, or he may add other constituents to the mix. All these variations will alter the nature of the product, and this flexibility of operation is one of the principal advantages of the process. A peculiar feature is that the vesicular sinter shrinks in size rather than expands as is characteristic of other burned shale aggregates. . . .

"Cel-Seal is made by pugging a mixture of soil and clay and forcing it through a die. It is then broken or cut into pieces of various sizes, each one of which is covered with a thin coating of fine silica sand, the sand coating serving to keep the fragments from sticking together. After burning in a rotary kiln the resultant clinkered particles are screened to the desired sizes."*

It is seen from the above descriptions that processes have been developed to utilize a variety of clays and fuels. The ease with which the Porters Creek clay and the Ackerman underclays develop a vesicular structure and the possibility of utilizing overlying beds of lignite in the manufacture of light-weight aggregate point to the feasibility of light-weight aggregate manufacture in Winston County. There are probably few, if any, localities in this country offering such natural advantages.

*Hughes, H. H., Scope of the light-weight aggregate industry: Am. Inst. Min. & Met. Eng., Tech. Pub. No. 405, 1931; Requoted here from Bulletin No. 45, Geol. Survey Georgia.

CLAYS OF THE ACKERMAN FORMATION—WEATHERED

EVERETTE CLARK PROPERTY

TEST HOLE 167 RECORD

Location: T. 14 N., R. 12 E., Sec. 21, E. ½, SW. ¼, SE. ¼ Drilled: June 14, 1938
Elevation: 190 feet Water level:

No.	Depth	Thick	Sample	Description of strata
1	0.8	0.8		Soil, top, light-brown to yellow
2	3.4	2.6	C–1	Soil, sub, yellowish-red sandy clay
3	5.0	1.6	C–2	Soil, sub, yellowish-red sandy clay
4	7.6	2.6	C–3	Clay, reddish-yellow; light-gray lumps of clay
5	9.8	2.2	C–4	Clay, reddish-yellow; light-gray lumps of clay
6	11.7	1.9	C–5	Clay, reddish-yellow; light-gray lumps of clay
7	13.6	1.9	C–6	Clay, plastic light-gray to yellowish-pink
8	15.8	2.2	C–7	Clay, yellow and gray mixed, slightly silty, semi-plastic to non-plastic
9	17.0	1.2	C–8	Clay, yellow and gray mixed, slightly silty semi-plastic to non-plastic, manganiferous-stained
10	18.8	1.8	C–9	Clay, light-gray, yellowish iron-stained silty
	18.8	18.8	9	Total

Remarks: Base for elevation, branch level 98 yards north of hole, east of Highway 15.

LABORATORY TESTS OF SAMPLE 167P1

Physical properties in the unburned state

Color: Grayish orange
Texture Fine, sandy
Workability: Good plasticity
Water of plasticity: 26.03 percent
Drying shrinkage: volume, 24.34 percent: linear, 8.90 percent
Modulus of rupture 460.0 pounds per square inch
Time of slaking: More than 2 hours
Drying behavior: No warpage or cracking

Screen analysis

Retained on screen	Percent	Character of residue
20		
30	0.75	Abundance of micaceous, limonitic sandstone and a small amount of ferruginous rock
60	12.70	Abundance of quartz; traces of clay and ferruginous material
100	6.90	Abundance of quartz; small amounts of microcline, hematite, plant fragments, and clay
150	1.70	Abundance of quartz, hematite; small amount of clay and a trace of magnetite
200	2.18	Abundance of quartz; considerable quantity of yellow clay and kaolin; small amounts of muscovite, ferruginous material, and a trace of magnetite
250	2.80	Considerable quantities of quartz, hematite, and muscovite; small amounts of feldspar, rutile, clay, and a trace of magnetite
Cloth	73.07	Clay substance; residue from above

Chemical analysis

Moisture, air dried	1.49	Soluble salts	0.10
Ignition loss	5.36	Lime, CaO	1.42
Silica, SiO_2	69.58	Magnesia, MgO	0.21
Alumina, Al_2O_3	15.81	Potash, K_2O	0.39
Iron oxide, Fe_2O_3	5.19	Soda, Na_2O	1.42
Titania, TiO_2	0.65	Sulphur, SO_3	Trace

PYRO-PHYSICAL PROPERTIES

At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
04	30.33	16.62	1.87	2.61	-.13	-.07	957	Salmon
02	29.28	15.81	1.85	2.59	1.72	.60	1118	Lt. red
1	28.05	14.75	1.87	2.61	2.88	.98	1285	Lt. red
3	27.26	14.58	1.89	2.64	3.93	1.35	1457	Med. red
5	25.90	13.17	1.90	2.65	4.54	1.56	1549	Med. red
7	24.48	12.94	1.96	2.50	6.66	2.29	1597	Med. red
9	21.48	10.89	1.97	2.51	7.01	2.42	1545	Dark red
11	18.63	9.47	1.97	2.42	8.77	3.01	1746	Brownish red
13	15.41	7.63	2.01	2.38	9.45	3.27	1781	Reddish brown
13½	7.39	3.59	2.05	2.22	12.91	4.54	N. D.	Brown
15	7.32	3.96	1.85	2.05	.99	.33	Fused	Brown

Steel hardness at cone 9 Best apparent burning range, cone 3 to cone 13½
Overburning temperature, cone 15

SUMMARY OF RESULTS

Clay 167P1, a composite of clays of Samples C1 to C9 inclusive, is typical of an unlimited quantity of surface clay which is available over a wide area in Winston County. The location of the test hole was determined by its economic and geographic position in respect to rail and highway transportation, power and fuel supply, accessibility and drainage of raw material, and nearness to a populated area where labor is plentiful. The location of the test hole is ideal for the location of a heavy clay products plant.

A screen analysis was made on each C sample. After passing 10-mesh screen, the combined amount of residue retained on screens 30, 60, 100, and 250 is as follows: C1, 48.04 percent; C2, 21.01 percent; C3, 31.73 percent; C4, 7.98 percent; C5, 7.73 percent; C6, 4.76 percent; C7, 4.60 percent; C8, 22.07 percent; C9, 7.47 percent. The residue consisted principally of quartz and ferruginous sandstone. Samples C1, C2, and C3 were highest in quartz and had ferruginous material estimated at 6 percent; samples C4, C5, C6, and C7 contained the least residue, which consisted of quartz and ferruginous material in approximately equal proportions; samples C8 and C9 are comparable to samples C4 through C7 except that the residue of sample C8 contained approximately 18 percent of ferruginous material. It is evident from the above that quartz and ferruginous material are not uniformly distributed throughout the different intervals. Quartz is in abundance in sample

C1 and decreases through samples C2 and C3, from where it appears rather uniformly through sample C9. The ferruginous material appears fairly uniformly through the different intervals except at C8. Samples C4 through C7 are most nearly free from coarse impurities and average 95 percent passing 250-mesh screen.

The composite sample 167P1 possesses excellent working qualities. Its plasticity is conducive to forming heavy clay products by extrusion with an auger. The clay dries fast and without warping or cracking. The dry strength is unusually high, and would be helpful in the manufacture of thin and intricate shapes by preventing loss of ware from cracking, chipping, and breakage during handling of the ware in forming, drying, and burning processes. The fired strength is moderate and fairly uniform throughout the burning range. The fired linear shrinkage is less than 1 percent at cone 1, and increases gradually to 4.54 percent at cone 13½; a very desirable characteristic for any clay. Porosity and absorption decrease from cone 04 through cone 13½. The clay becomes steel hard at cone 9, and is not overburned until cone 15. The fired colors of salmon, red, and brown are clear and bright and free from scum and efflorescence, which is attributed to the absence of soluble sulphates in appreciable amounts. The chemical analysis indicates that the ratio of silica to alumina is proper for salt glazing.

POSSIBILITIES FOR UTILIZATION

Building brick may be divided into two classes: common brick, used for backing and foundation purposes; and face brick, used on the exterior of facing walls. There are many gradations between common brick and good quality face brick, all of which are often used for the same purpose; consequently the two classes are becoming less distinguishable, and both common and face brick are called building brick. Clay 167P1 is suitable for making a good grade of all-purpose building brick. The fine red to brown colors of the burned clay would be very desirable for face brick. The clay is also suitable for making structural tile, such as hollow load-bearing wall tile, hollow partition and furring tile, hollow floor tile, and plain and salt-glazed silo and facing tile. Hard and porous drain tile can be made from the clay, and possibly salt-glazed sewer pipe. Clay from intervals C4 through C7 is suitable for the manufacture of roofing tile and flower pots.

CLAYS OF THE HATCHETIGBEE FORMATION

WILLIS WOOD PROPERTY

TEST HOLE 173 (OUTCROP) RECORD

Location: T. 14 N., R. 10 E., Sec. 18, NW.¼, SE.¼ Drilled: June 22, 1938
Elevation: Water Level:

No.	Depth	Thick	Sample	Description of strata
1	15.0	15.0	P–1	Clay-shale, silty bluish-gray where unweathered; tan where weathered; containing fossil leaves, stems, seeds; some pyrite in small pellets; and limonite sheets in weathered portions
	15.0	15.0	1	Total

Remarks: Outcrop along public road 18.5 miles west of Louisville near proposed route of Mississippi Highway 14, on north side of present road. Drainage sufficient; overburdened is not excessive and some of it could be worked into the shale. Stratigraphically, this outcrop is at the top of the Hatchetigbee (Grenada) formation.

LABORATORY TESTS OF SAMPLE 173P1

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Color: Dark gray Texture Fine, mealy
Workability: Fair Water of plasticity 29.64 percent
Drying shrinkage: volume, 12.05 percent: linear, 4.21 percent
Modulus of rupture 285.0 pounds per square inch Time of slaking: More than 2 hours
Drying behavior: Fair

SCREEN ANALYSIS

Retained on screen	Percent	Character of residue
20		Abundance of micaceous lignitic clay nodules; small amounts of pyrite and limonite
30	0.64	Abundance of clay; small amounts of pyrite, limonitic clay, ferruginous rock, quartz, and carbonaceous material
60	0.76	Abundance of clay; small amounts of pyrite, quartz, carbonaceous and ferruginous materials
100	0.49	Abundance of gray and limonitic clays and pyrite; small amounts of muscovite, quartz, carbonaceous material; and a trace of rutile
150	0.34	Abundance of clay, quartz; considerable quantity pyrite; small amounts of muscovite, carbonaceous material; and a trace of rutile
200	1.46	Abundance of quartz; considerable quantity pyrite; small amounts of clay, muscovite, carbonaceous material, and rutile
250	1.08	Abundance of gray clay; small amounts of limonitic clay, pyrite, muscovite, carbonaceous material, and kaolin
Cloth	95.23	Clay substance; residue from above

CHEMICAL ANALYSIS

Moisture, air dried	1.02	Soluble salts	0.25
Ignition loss	5.90	Lime, CaO	1.02
Silica, SiO_2	69.34	Magnesia, MgO	0.73
Aluminum, Al_2O_3	18.37	Potash, K_2O	0.07
Iron Oxide, Fe_2O_3	2.12	Soda, Na_2O	0.40
Titania, TiO_2	0.85	Sulphur, SO_3	0.37

PYRO-PHYSICAL PROPERTIES

At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in pounds per square inch	Color
04	35.63	21.96	1.62	2.52	1.23	.44	796	Lt. buff
02	31.63	18.36	1.72	2.51	7.38	2.53	1070	Lt. buff
1	31.21	18.34	1.71	2.49	8.92	3.09	1716	Buff
3	22.18	11.58	1.84	2.47	16.83	5.98	1877	Buff
5	21.03	11.37	1.92	2.35	17.33	6.17	2341	Greyish buff
7	15.59	7.88	1.98	2.34	19.81	7.13	2298	Greyish buff
9	12.41	6.00	2.09	2.33	25.77	9.47	3443	Greyish green
11	3.58	1.63	2.12	2.20	43.05	17.14	3624	Olive green
13	13.46	7.91	1.80	2.06	15.37	5.42	3400	Lt. olive green
15	Bloated							Lt. olive green

Steel hardness at cone 5 Best apparent burning range, cone 3 to cone 11
Overburning temperature, cone 13

SUMMARY OF RESULTS

Clay 173P1 was chosen as representing an abundance of surface clay in the western part of Winston County.

The clay has an oily or waxy plasticity and does not bond together in the plastic state as well as would be desired. However, the plasticity is such that heavy clay products could be made by the plastic process, but would be better if they were re-pressed. Improvement in working properties would likely be accomplished by coarse grinding. The high dry strength and low shrinkage in the unburned state are very desirable for heavy clay products. The clay develops good fired properties between cones 5 and 11; however, overburning begins quickly thereafter. The burned color of the clay changes rapidly with increase of heat treatment; consequently, it would be difficult to obtain a uniformly colored product in periodic commercial kilns.

POSSIBILITIES FOR UTILIZATION

This clay is suitable for making a good grade of common brick and a fair grade of face brick, provided the burned colors proved attractive. The ability of the clay in the plastic state to withstand strains developed in forming hollow structural clay products is somewhat doubtful; however, should this be overcome by an adjustment in commercial processes, the clay could be suitable for hollow load-bearing wall tile, hollow partition and furring tile, hollow floor tile, silo tile, and drain tile.

LIGNITE

EOCENE FORMATIONS

JOHN LOWRY OLD PLACE

TEST HOLE 3 RECORD

Location: T. 15 N., R. 12 E., Sec. 9, SW.¼, SW.¼, Drilled: Nov. 2, 1937
Elevation: 60 feet above bed of branch Water level: dry

No.	Depth	Thick.	Sample	Description of strata
1	5.1	5.1		Sand, yellow fine-grained argillaceous
2	6.4	1.3		Lignite, black weathered
3	6.9	0.5		Clay, chocolate-colored lignitic
4	10.5	3.6	C–1	Clay, grayish
5	11.6	1.1	S–1	Clay, yellowish silty
6	30.5	18.9		Sand, yellow fine-grained argillaceous
7	32.3	1.8	S–2	Sand, bluish lignitic, very argillaceous fine-grained micaceous; ferruginous rock at top
8	33.2	0.9		Sand, brownish fine-grained pyritiferous, argillaceous
9	33.7	0.5		Sand, bluish lignitic
10	35.1	1.4		Clay, black lignitic very fine-grained
11	38.9	3.8	C–2	Lignite, brownish-black pure; not very hard
12	40.1	1.2	C–3	Clay, plastic bluish-gray hard lignitic
	40.1	40.1	3	Total

Remarks: Sample C-3 is of top part lower underclay only.

E. P. RAINEY PROPERTY

TEST HOLE 15 RECORD

Location: T. 16 N., R. 12 E., Sec. 26, NE.¼, NW.¼ Drilled: Dec. 7, 1937
Elevation: Water level: 8.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	2.0	2.0		Soil, brown sandy
2	6.0	4.0		Sand, yellow fine-grained
3	13.2	7.2		Sand, white fine-grained
4	17.2	4.0	C–1	Lignite, hard black
5	21.6	4.4	C–2	Clay, dark-gray plastic; lignitic streaks
6	25.4	3.8	C–3	Clay, medium-gray to white, plastic slightly sandy
7	28.1	2.7	C–4	Clay, white semi-plastic sandy
8	28.3	0.2	S–1	Clay, dark-gray semi-plastic
	28.3	28.3	4	Total

Remarks: Samples of clay badly contaminated with sand and lignite. Hole abandoned at 28.3 feet in top of Porters Creek clay.

J. NAT WOODWARD PROPERTY

TEST HOLE 18 (OLD MINE) RECORD

Location: T. 15 N., R. 12 E., Sec. 21, NW.¼, NE.¼ Drilled: Dec. 17, 1937
Elevation: Water level:

No.	Depth	Thick.	Sample	Description of strata
1	not measured			Sand, salt and pepper-colored fine-grained slightly micaceous, argillaceous
2	4.0	4.0	P-1:C-1	Lignite, dark-brown to black fairly pure; contains a few flakes of clay throughout; blocky and coarsely jointed in lower part; at top, finely jointed with thin limonite fillings
3	16.0	12.0	P–2	Clay, dark-blue tough plastic; a very small amount of fine sand, at several levels; almost uniform
4	16.2	0.2		Clay, slightly sandy
5	16.4	0.2		Lignite
	16.4	16.4	3	Total

Remarks: Samples of lignite were taken 10.0 feet inside entrance of the J. Nat Woodward old lignite mine by stripping from a scalped surface. Sample of clay was taken in auger hole in drift on floor of mine at base of scalped lignite.

JOHN LOWRY OLD PLACE

TEST HOLE 70 RECORD

Location: T. 15 N., R. 12 E., Sec. 9, SW.¼, SW.¼ Drilled: Feb. 21, 1938
Elevation: 104.5 feet above bed of branch Water level: 22.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	0.4	0.4		Soil, top sandy
2	8.9	8.5		Clay, yellow to gray plastic, iron-stained
3	12.6	3.7	C–1	Clay, gray, slightly stained plastic
4	13.6	1.0	S–1	Clay, heavily yellow-stained
5	18.3	4.7	C–2	Clay, gray, slightly stained plastic slightly silty
6	22.8	4.5	S–2	Sand, very fine brownish-gray argillaceous
7	25.9	3.1	C–3	Clay, dark-gray tough micaceous
8	39.7	13.8	C–4	Silt, gray slightly plastic; very little, if any, mica
9	45.8	6.1	C–5	Lignite, hard brown to black contaminated
10	47.6	1.8	S–3	Lignite, soft brown contaminated
11	50.3	2.7	C–6	Clay, gray plastic
12	51.4	1.1	S–4	Silt, gray micaceous
13	51.7	0.3	S–5	Sand, yellow quick
	51.7	51.7	6	Total

Remarks: Hole abandoned at 51.7 feet on account of water and quick sand.

S. O. McCULLY PROPERTY

TEST HOLE 83 RECORD

Location: T. 15 N., R. 12 E., Sec. 23, NE.¼, NW.¼ Drilled: March 9, 1938
Elevation: 500 feet above sea level Water level: 18.5 feet

No.	Depth	Thick.	Sample	Description of strata
1	0.9	0.9		Soil, top brown loamy
2	7.5	6.6		Clay, yellowish-red semi-plastic; fine rock at depth of 5.5 feet
3	11.0	3.5		Clay, white, red-stained semi-plastic
4	13.9	2.9		Clay, light-gray semi-plastic; very little yellow stain
5	15.8	1.9		Clay, light-brown semi-plastic
6	17.9	2.1		Clay, brown to dark-gray silty micaceous semi-plastic
7	25.5	7.6	C–1	Lignite, hard brown
8	26.7	1.2	C–2	Clay, brownish to gray silty micaceous lignitic-stained, plastic, contaminated
9	27.7	1.0	C–3	Lignite, hard brown
10	30.2	2.5	C–4	Clay, brownish to gray silty micaceous tough lignitic-stained plastic
11	31.5	1.3		Clay, yellowish micaceous semi-plastic; rock
12	32.7	1.2	S–1	Sand, white badly contaminated fine-grained; some mica
13	33.8	1.1	S–2	Clay, gray to yellow silty plastic
14	34.4	0.6	S–3	Silt, whitish, yellow-stained micaceous
	34.4	34.4	4	Total

Remarks: Hole abandoned at depth of 34.4 feet in white silt.

S. O. McCULLY PROPERTY

TEST HOLE 84 RECORD

Location: T. 15 N., R. 12 E., Sec. 23, NE.¼, NW.¼ Drilled: March 9, 1938
Elevation: 503.0 feet above sea level Water level: 23.4 feet

No.	Depth	Thick.	Sample	Description of strata
1	0.4	0.4		Soil, top light-brown loamy
2	7.7	7.3		Clay, light-brown to reddish-yellow stained
3	13.4	5.7		Clay, light-gray, yellow-stained semi-plastic
4	14.1	0.7		Clay, yellow semi-plastic, little fine rocks
5	18.8	4.7		Clay, dark-gray silty micaceous semi-plastic
6	20.8	2.0	S–1	Clay, as above but with more mica and very small lumps of lignite
7	22.6	1.8	S–2	Clay, dark-gray silty micaceous semi-plastic; very small lumps of lignite; small lumps of pyrite at 21.3 feet
8	31.0	8.4	C–1	Lignite, hard brown
9	32.8	1.8	C–2	Clay, brownish to gray silty micaceous lignitic-stained
10	33.6	0.8	C–3	Lignite, brown
11	36.7	3.1	C–4	Clay, brownish to gray silty micaceous lignitic-stained tough plastic; small yellow rock at 35.0 feet
12	37.9	1.2	S–3	Clay, yellow iron-stained very silty micaceous semi-plastic, small rock
13	38.3	0.4	S–4	Sand, fine-grained white micaceous; badly contaminated
	38.3	38.3	4	Total

Remarks: Hole abandoned at depth of 38.3 feet, on account of water and fine sand.

V. J. HUMPHRIES PROPERTY

TEST HOLE 172 RECORD

Location: T. 14 N., R. 11 E., Sec. 24, NW.¼, NE.¼ Drilled: Trench
Elevation: Water level:

No.	Depth	Thick.	Sample	Description of strata
	2.0	2.0	C–1	Lignite, firm dark-brown to black pyritiferous; contains thin streaks of clay. The lower part of lignite appears to be earthy. A little very fine-grained dark bluish-gray clay shows under lignite; thickness not determined.
	2.0	2.0	1	Total

Remarks: Trench dug approximately 10.0 feet east of Fox Spring. Top part of the lignite has been weathered, and indications are that the seam is 3.0 feet to 4.0 feet thick.

LABORATORY TESTS OF SAMPLES 3C2, 15C1, 18P1, 70C5, 83C1, 84C1, 172C1

ANALYSIS

Sample No.	Ash in percent	Volatile combustible matter in percent	Fixed carbon in percent	Volatile sulphur in percent	Calorific value B.T.U. per pound
3C2	16.06	46.45	37.49	0.78	8763
15C1	43.00	29.33	27.67	3.72	5062
18P1	10.92	45.58	43.49	1.08	9973
70C5	28.99	39.71	31.30	2.25	7369
83C1	26.73	37.61	35.66	1.03	7164
84C1	29.26	37.26	33.48	0.94	6820
172C1	10.33	46.44	43.23	1.55	10008

Natural water content of sample No. 18P1 is 48.2 percent

Note: Above values based on dry weight, 110°C.

POSSIBILITIES FOR UTILIZATION

Lignites, represented by samples 3C2, 18P1, and 172C1, are comparable in quality to the better grades of lignite found in other parts of the United States. Samples 15C1, 70C5, 83C1, and 84C1 were contaminated by earthy material. The pulverulent condition of these samples as received at the laboratory made it impossible to determine whether the earthy material was an inherent part of the lignite or whether it was accidently added through drilling operations.

Lignite is used as a fuel in localities where it is more economical than coal. As long as coal can be shipped into Winston County at a moderate price, it is not likely that the lignites will be utilized as a substitute for coal. Lignite may supplement the present fuel supply, provided mining operations could be accomplished economically.

The most promising use for the lignites appears to be in connection with the manufacture of light weight aggregate for concrete from the Ackerman underclays, as suggested in a previous part of this report.

SAND

R. G. BROWN, JR., PROPERTY

TEST HOLE 36 RECORD

Location: T. 14 N., R. 14 E., Sec. 21, SW.¼, SE.¼ Drilled: Jan. 26, 1938
Elevation: 59.2 feet Water level: 50.0 feet

No.	Depth	Thick.	Sample	Description of strata
1	8.1	8.1		Sand, medium fine red
2	10.1	2.0		Sand, light yellow
3	12.7	2.6		Sand, white very fine
4	13.7	1.0		Clay, whitish
5	14.4	0.7		Clay, yellowish
6	18.0	3.6		Silt, white
7	22.8	4.8		Silt, yellowish
8	52.0	29.2	P-1	Sand, white
	52.0	52.0		Total

Remarks: Hole abandoned at 52.0 feet on account of water and quick sand.
Datum: Floodplain below test hole 42.

LABORATORY TESTS OF SAMPLE 36P1

SCREEN ANALYSIS

Retained on screen	Percent	Character of residue
20		Abundance of quartz and a small amount of muscovite
30	5.45	Abundance of quartz and a small amount of muscovite
60	27.67	Abundance of quartz and a small amount of muscovite
100	57.00	Abundance of quartz and a small amount of muscovite
150	4.65	Abundance of quartz and a small amount of muscovite
200	1.71	Abundance of muscovite and a considerable quantity of quartz
250	0.26	Abundance of muscovite and a small amount of quartz
Cloth	2.80	Clay substance including residue from above

CHEMICAL ANALYSIS

Moisture, air dried	0.10	Soluble salts	0.25
Ignition loss	1.19	Lime, CaO	0.84
Silica, SiO_2	91.60	Magnesia, MgO	1.70
Alumina, Al_2O_3	4.28	Potash, K_2O	0.03
Iron oxide, Fe_2O_3	1.03	Soda, Na_2O	0.07
Titania, TiO_2	0.25	Sulphur, SO_3	Trace

POSSIBILITIES FOR UTILIZATION

Sand, represented by sample 36P1, is suited for use as an aggregate in white to light colored cement mortar, cement plaster, and as the principle ingredient in pre-cast artificial sandstone and limestone. It is suitable for use in concrete building block, concrete sewer pipe, drain tile, and other manufactured concrete shapes. The manufacture of sand-lime brick is a possibility. In ceramics, the sand would be desirable for use as a placing sand and as a non-plastic in light colored brick.

LABORATORY PROCEDURE

CLAYS

PREPARATION

Preliminary drying of the clays was unnecessary, for they had been collected from the field and stored in a steam-heated room several months prior to testing. Primary samples of about 200 pounds were crushed in a No. 2 jaw crusher. The crushed material was screened through a No. 20-mesh Tyler standard screen; the residue coarser than 20-mesh was ground in a burr mill until it passed the 20-mesh screen. The final bit of residue remaining on the 20-mesh screen was collected for examination, the description of which appears in the tables of screen analyses under the designation "Residue retained on screen No. 20." The clay which had passed 20-mesh screen was thoroughly mixed and reduced to a 10-pound sample by coning and quartering. This operation was accomplished in a metal lined tray approximately 4 feet square and 8 inches deep. The 10-pound sample was reserved for screen 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 three sizes: cubes, 1 inch square; short bars, 1 inch square by 2 inches long; long bars, 1 inch square by 7 inches long. The test pieces were made by wire-cutting bars of approximate size from the plastic mass and then pressing them in molds to the final size. The long bars were pressed by hand in a hardwood mold of the plunger type. The short bars were formed in a Patterson screw press fitted with a steel die. The 1 inch cubes were cut from short bars. Each test piece was identified as to test hole number, sample number, and individual piece number. The identification was made by stamping the necessary letters and numerals on the test pieces. A shrinkage mark of 10 centimeters was stamped on the long bars. Sixty long bars, 100 short bars, and 4 cubes were made from each primary clay sample. Certain C samples were not large enough to make the full number of test pieces.

PLASTIC, DRY, AND WORKING PROPERTIES

Immediately on forming the short bars their plastic volume was determined in an overflow volumeter of the Schurecht type, using kerosene as the liquid. The plastic weight was measured to .01 gram using a triple beam balance. All of the test pieces were allowed to air-dry several days on slatted wooden pallets and then were oven-dried by gradually increasing the temperature of the oven from room temperature to 100°C. in 4 hours and maintaining the oven temperature between 100°C. and 110°C. for an additional hour. After drying, the short bars and cubes were placed in dessicators, and on cooling to room temperature they were reweighed and placed in kerosene to soak 24 hours, after which, their volumes were taken as above described. The 1 inch cubes were slaked in water in accordance with the procedure outlined by the American Ceramic Society. Ten long bars were broken on a Fairbanks cross-breaking machine to determine modulus of rupture.

The workability of the clay was observed during grinding, wedging, and the forming of the test pieces. Clays having a suitable plasticity were formed into pottery shapes by throwing on a potters wheel. Where the quantity of clay permitted, standard size brick were made in a hand mold for the purpose of observing drying characteristics of thick bodies. The water of plasticity, modulus of rupture, and volume shrinkage, were calculated by methods outlined by the American Ceramic Society. The linear shrinkage was calculated from the volume shrinkage and checked against the linear shrinkage measured from the long bars.

The slaking test was made by placing four 1 inch cubes on a one-quarter inch mesh screen wire submerged 2 inches in water. The average time required for the 4 cubes to disintegrate and completely pass through the screen was the time of slaking. Certain clays disintegrated into flakes which clogged the wire screen and only a small portion of the clay passed through the screen. The time of slaking for these clays was noted as "more than two hours" inasmuch as they had not completely passed through the screen in that length of time.

FIRED PROPERTIES

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

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

After the firing of the long and short 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 was kept boiling for four hours. They were allowed to cool in the water to room temperature and were reweighed as before mentioned. Immediately thereafter the volumes of the test pieces were determined in a Schurecht volumeter using water as the liquid. Volume shrinkage, porosity, absorption, bulk specific gravity, and apparent specific gravity were calculated in accordance with methods outlined by the American Ceramic Society. The long bars were broken on a Fairbanks testing machine to determine modulus of rupture. Five long bars were burned and tested for each clay at each cone temperature indicated in the table of pyro-physical properties. Three short bars were fired as test pieces and six additional short bars were fired as check pieces for each clay and at each cone.

CONVERSION TABLE

CONES TO TEMPERATURES

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

Cone No.	When heated at 100°C. per hour		Cone No.	When heated at 100°C. per hour	
	°C.	°F.		°C.	°F.
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.

SCREEN ANALYSIS

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

The disintegrated clay in slip form was poured through a nest of Tyler standard screens, the sizes being 30, 60, 100, 150, 200, and 250-mesh. The material passing through the 250-mesh screen was caught on a cloth in a plaster vat. After a fair sample was caught on the cloth, the screens, still in nest, were washed with a stream of water until no further material passed through the screens.

The screens were dried at 110°C., after which, the residue from each screen was weighed and collected in glass vials for further study.

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

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

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

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

THERMAL DEHYDRATION

Exactly 40 grams of clay which had been previously washed through the 250-mesh screen and dried to constant weight at 100°C. 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 50°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 50° 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.

CHEMICAL ANALYSIS

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

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

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

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

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

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

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

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

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

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

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

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

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

Soluble salts: Ten grams of each clay were accurately weighed and boiled in 100 cc. of water to which 10 cc. of HCl were added. The precipitates were allowed to settle and 10 cc. portions of $BaCl_2$ solution (1 cc. equivalent to .001 gram SO_4) were run in. After each addition the solutions were stirred, allowed to settle, and one drop added to a drop of dilute H_2SO_4 on a spot plate. As soon as a white precipitate formed in one spot the percent of soluble salts was taken as the number of cc. run in divided by 100.

Soluble and insoluble valuation: (This test is a measure of uncombined alumina and iron as determined in laboratories of The

Aluminum Company of America.) Twenty-five grams of the sample were refluxed one hour with 60cc. of 48 percent H_2SO_4. One hundred and fifty cc. of boiling water were added through the condenser and the flask removed and cooled. It was then filtered by suction and the insoluble residue ignited in a large porcelain crucible. This was weighed as insoluble. The filtrate was diluted to 1 liter and 200 cc. removed and diluted to 1 liter. Of the latter solution 100 cc. was used for alumina and iron determination by precipitation with NH_4OH, filtration, ignition, and weighing. Iron was determined in a separate 50 cc. portion, after $SnCl_2$ reduction, by titration with potassium dichromate using diphenylamine indicator in the presence of sulfuric and phosphoric acids.

LIGNITE

CHEMICAL ANALYSIS AND CALORIFIC DETERMINATION

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

Moisture: No attempt was made to determine moisture on any of the samples except 18P1 of which a sealed sample was available. A 10-gram sample was heated in an oven at 110° C. for an hour.

Ash: One gram samples were used for ash determination. The heating was slow and careful at first. Later a platinum wire was used to stir the contents of the crucible. Silica crucibles were used for this determination as the wear on platinum is considerable.

Volatile combustible matter: This determination was made in a special fused quartz crucible with a cover. One gram of the lignite was placed in the crucible which was then suspended in an electric furnace heated to 950°C. The crucible was left in the furnace for exactly seven minutes, according to a stop watch, then taken out, cooled, and loss in weight determined.

Fixed carbon: This was determined by adding the ash and volatile combustible matter and subtracting from 100.

Calorific value: Calorific value was determined by using a Parr bomb calorimeter and following instructions in Scott, "Standard methods of Chemical Analysis" for methods for analysis of fuels.

Volatile sulfur: This was determined in the bomb washings after a calorific determination. The washings were filtered and the sulfur precipitated as barium sulfate, filtered off, ignited and weighed

SANDS

The chemical analysis and screen analysis of sands were made by using the same procedure followed in analysing clay.

Plate I

Provisional map of Winston County showing the distribution of the geologic formations in five areas, on one of which the Betheden is represented by hachures, and on four of which outliers of younger formations are shown without names. The map also shows the locations of test holes by circles and numbers.---By Frederic Francis Mellen, M.S.

Stratigraphic sequence

- Cenozoic group
  - Eocene system
    - Claiborne series
      - Tallahatta formation
    - Wilcox series
      - Hatchetigbee formation
      - Holly Springs formation
      - Fearn Springs and Ackerman formations
    - Midway series
      - Porters Creek and Betheden formations