Mississippi
State Geological Survey

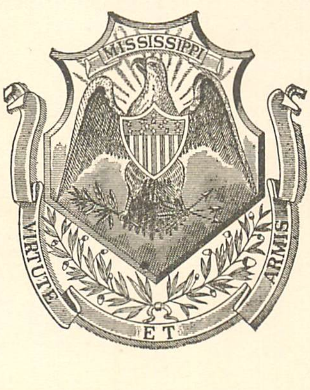
E. N. LOWE, DIRECTOR.

BULLETIN No. 6

THE POTTERY CLAYS OF MISSISSIPPI

BY

WILLIAM N. LOGAN



BRANDON-NASHVILLE

STATE GEOLOGICAL COMMISSION.

His Excellency, E. F. Noel .... *Governor*

Dunbar Rowland .... *Director of Archives and History*

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LETTER OF TRANSMITTAL.

State Geological Survey,

Jackson, Miss., November 30, 1909.

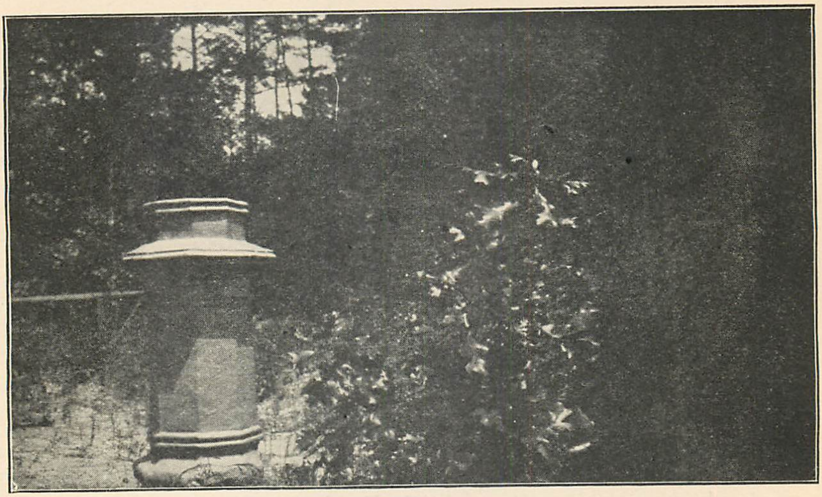
To his Excellency Gov. E. F. Noel, Dr. Dunbar Rowland, Chancellor A. A. Kincannon, Pres. J. C. Hardy, and Supt. J. N. Powers, Members of the Geological Commission.

Gentlemen: I submit herewith a report on the Pottery Clays of Mississippi by Dr. William N. Logan, and respectfully recommend its publication as Bulletin No. 6 of the Mississippi Geological Survey Publications.

Very respectfully,

E. N. Lowe,
Director.

PLATE I.



A. TERRA COTTA URN MADE OF WILCOX CLAY AT LOCKHART.

B. TERRA COTTA URN MADE IN IMITATION OF TREE AT LOCKHART.

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INTRODUCTION.

The ceramic industry of our country is of more importance economically than is apparent to casual observation. The clay products of the United States exceed in value by nearly thirty millions dollars the total amount of the gold and silver mined in the United States, including Alaska. They exceed in value by sixty millions dollars the value of the iron ore mined in the United States annually. All of the silver, lead and zinc produced annually in our country is not as valuable by more than fifty millions dollars as the clay products of the same period. These facts should be sufficient to convince anyone of the importance to the State of the development of its ceramic resources.

The ceramic industry of Mississippi has not developed to that extent which is warranted by the quality and quantity of its resources. During the past few years there has been a decided improvement in our methods of brick manufacture, with a corresponding increase in the quality of the ware. The manufacture of drain tile has been introduced and the fact that we have clays suitable for its manufacture has been thoroughly demonstrated. In the manufacture of pottery, however, there has been little advance. At the present time there is but one steam pottery in operation in the State. In 1907 the total products of the potteries of Mississippi were valued at $21,121. The pottery products of Ohio for the same year were valued at $13,533,199. Mississippi held twenty-ninth rank among the clay producing States for that year, the total value of our clay products being estimated at $846,529. Of this amount, $18 200 is credited to drain tile, $20,769 to face or front brick, $865 to red earthenware, $20,256 to stoneware and the remainder to common brick. The total clay products of Ohio for the same period were valued at $30,533,199, and of Pennsylvania at $20,291,621.

The potteries of Ohio and New Jersey receive the larger part of their supplies of kaolin and ball clay from the Southern States. It is to be hoped, therefore, that a better knowledge of our raw materials will lead to a more rapid development of our pottery industry on

Southern soil. As this report contributes to that knowledge to that extent will it have fulfilled its mission.

In a former report on the brick clays of Mississippi a discussion of the technology of clays was given, and in the present report the subject is again treated. However, a certain amount of repetition seems warranted by the fact that the reports are designed to be of assistance to separate and, in a large measure, distinct classes of clay workers. A very important line of work which has been undertaken was not completed in time to be included in this report. This work is the comparison of the results of tests on the physical properties of the clays with those of certain clays used as standards.

CHAPTER I.

ORIGIN AND USE OF CLAYS.

Definition.—Clay is a soft rock which is usually smooth or greasy to the touch. When mixed with the proper proportion of water it may be readily molded into desired forms which will have the power of retaining their shape. This property, plasticity, is not possessed in a high degree by other rocks, and is therefore one of the determinative characters of clay. Clay is a mechanical mixture of minerals. The proportion of these mineral constituents may vary; hence the composition of clays varies greatly. Aluminous clays are those containing a large quantity of the mineral kaolinite, which is the basis of all clays. Arenaceous clays contain a large quantity of sand. Calcareous clays contain much carbonate of lime. Ferruginous clays are those containing a considerable proportion of some iron compound.

Clay group of rocks.—The rocks which contain clays in such abundance as to be classed in the clay group of rocks are: kaolin, clay, shale, loam, loess, till and soil. The term kaolin is applied to beds of pure residual clays. Common clay is a mixture of kaolin and sand and other impurities. Shale is a consolidated clay, which is discussed under a separate head. Loam is a mixture of clay and sand. Loess is a fine rock-flour, containing clay, which has been produced by glacial erosion. Till is a clay which has been deposited by glaciers. Soil is usually a mixture of clay and other rock particles with organic matter. Some soils are used for clay purposes, such as manufacture of brick, ballast and drain tile.

ROCKS WHICH ARE THE SOURCES OF CLAY.

Clay may result from the decomposition of the following groups of rocks:

A. Sedimentary Rocks	1. Shales. 2. Argillaceous limestones. 3. Argillaceous sandstones.
B. Igneous Rocks......	1. Granite. 2. Syenite.
C. Metamorphic Rocks	1. Slate. 2. Gneiss. 3. Schist.

Shale.—Shale is compressed clay which has a form of cleavage causing it to split into flakes or blocks. Its physical properties are similar to those of clay, though it is usually harder and more dense. Shale is formed of clay which has been carried by the action of streams from the land and deposited either in the sea or in lakes. After deposition the clay is subjected to the pressure of overlaying rocks, and to crustal movements which increase its density and develop its structure. Since the clay particles are smaller and lighter than other rock fragments, they are carried farther out. The sorting action may result in beds of marked purity. The color of shales is generally dark or blue, and is due to the presence of either some iron compound or of organic matter. The removal of the coloring matter by weathering usually results in lighter colors. By weathering shales are reduced to beds of loose clay.

Limestone.—Limestone is composed, for the most part, of calcium carbonate, derived from the skeletons of animals. All marine animals secreting either an endo-skeleton or an exo-skeleton may contribute to the formation of such beds. Deposits of coral form one of the chief sources of such lime material. Skeletons of shell fish dropped within the littoral zone of the sea become broken and the fragments cemented together to form shell rock, which by further changes may form compact limestones. Shells of animals of microscopic size form beds of chalk, sometimes of great extent and thickness.

Land derived materials, such as sand and clay, are often deposited with the calcareous material, thus forming impure limestones. By the weathering of limestones containing the latter, beds of residual clay result.

Sandstone.—Sandstone is a rock formed of grains of sand bound together by some cementing substance. The cement may be iron, lime or silica. Coarse sandstones are composed of large sand grains. Where the grains are small the texture of the rock is fine. Sandstones may be massive or stratified. Crossbedded sandstones are those in which the bedding planes do not lie in parallel lines, but in which one set of planes lies oblique to another set. The color of sandstones is usually dependent on the presence of films of coloring matter coating the individual grains. Some sandstones contain more or less clay, the sand grains and the clay grains being deposited at the same time. Such argillaceous sandstones under the influence of weathering agents give rise to residual clays.

Granite.—Granite is a crystalline rock of igneous origin. It is composed mainly of varying amounts of feldspar, mica, quartz and hornblende, with very much smaller amounts of other minerals. The crystals are usually of microscopic size and closely interlocked. The color of the granite is largely dependent on the feldspar, which is usually either pink or gray. The disintegration and the decomposition of granite result in the formation of beds of sand and kaolin, the former being derived from the quartz and the latter from the feldspar. Whenever granite, under the influence of metamorphic action, has become foliated, it forms a rock termed gneiss.

Syenite.—This is a variety of igneous rock. It is composed of a mixture of feldspar and mica or hornblende. All of these minerals contain aluminum in the silicate form and therefore the decomposition of syenite causes the formation of beds of kaolin and clay.

Slate.—Slate is a metamorphosed clay or shale. The clay or shale has become indurated and has had a form of cleavage developed, probably by pressure. Beds of slate are usually intersected by joint planes. By the weathering of slate, beds of clay may result.

Gneiss.—This rock is often produced by the metamorphism of granite. It is a foliated rock with its minerals arranged in bands so as to give the false impression of stratification. Since gneiss often contains the same minerals as granite, the decay of gneiss may produce beds of clay.

Schist.—The metamorphism of a gneiss may produce a schist. The minerals of which the gneiss is composed may become completely separated into layers in a schist. The rock splits readily along certain planes. A mica schist or a quartz schist are schists in which the predominant mineral is mica or quartz.

THE DECOMPOSITION AND ALTERATION OF ROCKS.

The disintegration of rocks is brought about by the action of two sets of forces. The internal dynamical forces of the earth produced by the loss of heat and consequent shrinkage of the earth, result in faulting, folding, oscillation and deformation, accompanied by vulcanism and earthquakes. These movements disrupt the rocks and contribute to their decay.

The forces of the atmosphere, the hydrosphere and the life sphere are agents of destruction. Air which contains nitric acid, carbon dioxide, oxygen and watery vapor is an active agent of rock decay. Fresh faces of rocks soon lose their brightness and freshness under the corroding effect of the atmosphere.

Sudden changes of temperature set up strains in rocks which they are not able to withstand, and consequently they are broken up, and their fragments exposed to other weathering agents. The wind catches up particles of rocky material, blows them with violent force against the surface of rocks and wears them away.

Water running over the surface of rocks wears them by means of the rock particles which it carries with it. Falling water beats upon and erodes the surface of soft rock. Waves erode the rocks on the shores, breaking them apart and using the fragments as tools for further destruction. Water also exerts a chemical action on rocks. Some rocks may be dissolved by pure water, but others are soluble only in waters containing acids.

Limestones, which yield readily to the action of acid-bearing waters, are dissolved and carried away in large quantities by surface and underground waters which contain acids derived from decomposing minerals and organic matter. Caverns, sinkholes and underground streams and passages which represent the dissolved and eroded portions of limestone beds are generally characteristic of limestone regions. Carbon dioxide formed by plant decay and collected from the atmosphere by falling water is one of the most important solvents.

In the presence of moisture oxygen becomes an effective agent of rock decay. Compounds of iron in the rocks are attacked by oxygen and decomposed, thus contributing to the decay of the rock.

The process of oxidation may be accompanied by the process of hydration, in which case the oxidized mineral takes up water. Hydration usually produces a softer mineral, one more easily eroded and thus weakens the rock.

Roots of trees growing in crevices exert a mechanical action which splits the rocks apart, and a chemical action which dissolves them by virtue of vegetable acid from the roots. Man, by digging wells, excavating tunnels and cultivating the soil also breaks up the rocks.

ORIGIN OF CLAY.

The decomposition and the alteration of rocks containing silicates of aluminum is the source of clay. The group of silicates known as feldspars constitutes the most fruitful source of clay. Feldspar is one of the principal constituents of granite and other igneous or metamorphic rocks of the granitoid group. For this reason the formation of residual deposits of clay is closely associated with the disintegration of granite and the subsequent alteration of its silicate minerals.

The disintegration and decomposition of granite is accomplished by the various mechanical and chemical agents which are actively engaged in rock weathering. The alteration of the silicates is accomplished by the action of mineral and vegetable acids carried through the pores of the rock by circulating waters.

One of the most destructive of these acids is carbonic acid (H_2CO_3). This acid first attacks the potash and soda, hence silicates containing these bases are the first to be broken up. Lime and magnesia compounds are next attacked then the silicates containing iron, and lastly the aluminum silicates, the most stable of the compounds. These complex compounds having been broken up into their component elements, reactions between the elements occur and new compounds are formed. Aluminum uniting with silicic acid forms new silicates which are free from the other bases, and, since they are more readily soluble, are carried away by circulating waters.

The aluminum silicates thus formed are kaolinite, cimolite, halloysite, collyrite, schrötterite, etc.; also some oxides or hydroxides of alumina, such as gibbsite. These aluminous minerals form beds of rock called kaolin. Kaolin is the basis of all clays. The purity of a clay depends upon the percentage of kaolin which it contains. The higher the percentage of kaolin the purer the clay.

The other minerals which are usually associated with kaolin in clays are quartz, calcite, hematite, siderite, limonite, pyrite, feldspar, mica, rutile, lignite and dolomite. The kind and the quantity of these mineral impurities affect greatly the usefulness of the clay. The impurities may have originated from the decomposition of the rock which formed the clay, or they may have been deposited in the clay by circulating waters. The quantity of kaolin present and the amount and nature of the impurities serve as a guide to the uses for which clay may be employed, but the physical properties of the clay must also be considered.

CLASSIFICATION OF CLAY ACCORDING TO ORIGIN.

The following outline suggests a method of classification of clay deposits according to their origin:

I. Residual clay.
- A. Clays derived from igneous rocks.
  - *a.* Kaolin, derived from granite and other feldspathic rocks.
  - *b.* Ferruginous and impure kaolin, derived ordinarily from igneous rocks containing hornblende and other ferro-magnesian minerals.
- B. Clays derived from metamorphic rocks.
  - *a.* Kaolin, derived from gneiss and from other feldspathic metamorphic rocks.
  - *b.* Impure kaolin or clay, derived from slate, schist or argillaceous marbles.
- C. Clays derived from sedimentary rocks.
  - *a.* Surface clay, derived from shale.
  - *b.* Surface clay, derived from argillaceous limestone.
  - *c.* Surface clay, derived from argillaceous sandstone.

II. Transported clays.
- A. Fluvatile clays, those transported by streams.
  - *a.* Delta clays, those deposited in deltas.
  - *b.* Estuary clays, those deposited in the broad mouths of rivers.
  - *c.* Flood-plain clays, those deposited on the flood plain of rivers.
- B. Lacustrine clays, transported and deposited in lakes.
- C. Marine clays, transported and deposited in marine waters.
  - *a.* Unconsolidated beds of clay.
  - *b.* Shales, compact laminated clays.
- D. Glacial clays, those transported by ice.
  - *a.* Till.
  - *b.* Loess (in part).
- E. Eolian clays, transported by winds.
  - *a.* Loess (in part).
  - *b.* Adobe clays.

Residual clay.—Residual clays are beds of kaolin or the more common varieties of clay formed in place by the decomposition of other rocks. As has already been stated, the disintegration of the rocks is brought about by weathering. The alteration of the constituent minerals is accomplished by acids carried by meteoric waters. The depth to which kaolinization may take place is necessarily limited to a thin outer zone of the lithosphere. Very rarely such deposits are of greater thickness than 100 feet, and the greater majority would fall within the limit of a fourth of that thickness.

In exceptional cases kaolinization is thought to be produced by ascending solutions. Under such conditions the deposits may extend to depths greater than those produced by the action of surficial agents. The following table, compiled from Merrill's Rocks, Rock Weathering and Soils, pp. 215–17, illustrates the loss of constituent minerals which crystalline rocks may suffer during decomposition:

TABLE 1.

LOSS OF CONSTITUENT MINERALS IN THE DECOMPOSITION OF CRYSTALLINE ROCKS.

	Gneiss.		Phonolite.		Syenite.		
Constituent	*Fresh*	*Decomposed*	*Fresh*	*Decomposed*	*Fresh*	*Decomposed*	
Silica (SiO_2)	60.69	45.31	55.67	55.72	59.70	58.50	46.27
Alumina (Al_2O_3)	16.89	26.55	20.64	22.19	18.85	25.71	38.57
Iron oxide (Fe_2O_3)	9.06	12.18	3.14	3.44	4.85	3.74	1.36
Lime (CaO)	4.44	Trace	1.40	1.28	1.34	.44	.34
Magnesia (MgO)	1.06	.89	.42	.44	.68	Trace	.25
Potash (K_2O)	4.25	2.40	5.56	6.26	5.97	1.96	.23
Soda (Na_2O)	2.82	1.10	7.12	2.65	6.29	1.37	.37
Phosphoric acid (P_2O_5)	.25	.47	.....	.....	.....	.....	.....
Ignition	.62	13.75	4.33	7.79	1.88	5.85	13.61
Total	100.08%	99.98%	98.28%	99.77%	99.56	%97.57	%101.00%

The first analysis under decomposed syenite represents the first stage in decomposition, while the second analysis represents the last stage in which a kaolin-like residue is produced. The increase in the amount of alumina in all the decomposition products is very noticeable.

Residual clays also result from the decomposition of some limestones and sandstones. Limestones containing just a small per cent of clay, will often form clay beds of appreciable thickness through long continued decomposition. Calcium carbonate is dissolved out by meteoric water containing acids and the insoluble clay accumulates. The cementing material of sandstones is dissolved and sand particles and clay particles thus freed are separated by the sorting action of running water. The following analysis of limestone and its residual product exhibit the loss of constituent minerals by decomposition:

TABLE 2.

LOSS OF CONSTITUENT MINERALS IN THE DECOMPOSITION OF LIMESTONE.

Constituent	Limestone 1 *Fresh*	Limestone 1 *Decomposed*	Limestone 2 *Fresh*	Limestone 2 *Decomposed*	Limestone 3 *Fresh*	Limestone 3 *Decomposed*
Silicon dioxide (SiO_2)	32.81	63.63	20.60	65.30	17.03	76.60
Aluminum oxide (Al_2O_3)	11.15	10.34	7.63	12.63	21.00	18.37
Iron oxide (Fe_2O_3)	4.65	8.75	4.62	12.18	3.33	2.00
Calcium oxide (CaO)	22.69	3.75	41.81	1.50	29.29	.90
Magnesium oxide (MgO)	1.53	.50	.81	.63	.....	.....
Sulphur trioxide (SO_3)	1.55	.34	.25	.25	.72	.70
Moisture (H_2O)	2.75	4.25	.85	4.75	.75	.55
Volatile matter (CO_2, etc.)	22.61	7.77	23.15	2.27	28.20	.97
Total	99.74%	99.33%	99.72%	99.51%	100.32%	100.09%

These samples were taken from the Selma chalk and the residual clay overlying it.

Transported clay.—The residue formed by the decomposition of rocks may not be allowed to remain on the surface where it was formed. By the action of gravity, of water, of wind, or of ice it may be transported and deposited at some distant point. The particles of such residuum accumulating upon a slope will, influenced by gravity, gradually creep to the bottom of the slope. The water which falls upon the slope and runs away to the lower levels to form the rills, brooks and larger streams becomes filled with the finer particles, the size of the particles carried being dependent on the velocity of the water, which in turn, is dependent upon the slope. A stream having a velocity of only one-third of a mile an hour is sufficient for the transportation of clay particles. Because of the minute size of the particles and their light weight, clay is one of the first materials to be taken away from a residual deposit by running water. Whenever the stream carrying the particles retards its velocity, it drops its load in proportion to the loss of velocity. A small decrease in velocity will cause the loss of only the coarser particles. A sudden and complete loss of velocity would mean the deposition of all sizes of the materials held in suspension. The presence of coarse sand in clays may thus be explained. Rivers may carry fine particles of rock material to lake or sea and as the waters of the stream mingle with the waters of the larger body, they lose their velocity and deposit their load. Thus it is that estuary and delta deposits are formed. Carried by ocean currents and redeposited on the subaqueous coastal shelf, beds of marine sands and clays are formed, the coarse material being deposited nearest the shore. Deposits of sand, silt and clay are made on the flood plains of rivers during the overflow periods. The coarser material is thrown down near the banks of the stream, where the water on leaving the channel loses the greater part of its velocity and therefore its capacity for carrying suspended matter. The finer material is carried farther from the channel and, by the sorting action of water, beds of almost pure clay, the finest material, may be found upon the flood-plain.

Lacustrine clays are clay deposits formed along the shores and on the bottom of lakes, the material of which is derived from the land and carried in by streams. In a similar way marine clays are formed on the ocean bed. When these clay beds, in the course of deposition, become deeply buried under other deposits they become compacted into a firm clay rock called shale.

During the glacial period vast quantities of rock material were transported by ice and deposited in an irregular sheet of mantle rock, to which the name "drift" has been applied. The drift contains in many places beds of clay called till. Streams of water coming from the front of the melting glaciers carried away the fine particles of clay and rock flour and spread them in some places over large areas. This fine, silty material is called loess. Part of the loess was transported and redeposited by winds, thus producing our second form of loess deposits under the head of eolian origin.

USES OF POTTERY CLAYS.

Pottery clays are used for a variety of purposes. Every year new ceramic products are manufactured and the field of usefulness of pottery clays is thereby extended. So rapidly is the development of the industry taking place that the dawn of the ceramic age seems near at hand. The uses of the low grade clays of Mississippi have been mentioned in the report on the brick clays. In the following pages some of the uses to which our medium and high grade clays may be put are suggested.

FIRE BRICK.

Clays which exhibit a high degree of refractoriness may be employed in the manufacture of fire brick. Such brick are used in the construction of ovens, and furnaces, and also as linings for fire places, fire boxes and stoves. Fire brick are made of a mixture of clays and "grog." The "grog" which is added to diminish shrinkage may be either sand, crushed brick or burned clay. The brick may be molded by hand or by soft-mud or stiff-mud machines.

Glass Pots.

In the manufacture of pots for holding molten glass refractory clays are used. Clays used for glass pots must be plastic and be able to withstand a high degree of temperature. The bonding power of glass pot clay must be sufficient to hold a large percentage of grog.

Saggers, Sagger Pins, Spurs and Stilts.

Refractory clays, together with crushed burned clay, are used in the manufacture of saggers which are used for the protection of domestic and other wares from the combustion products of the kiln. Sagger pins are small triangular bars of clay which are inserted in depressions in the sides of the sagger and support flat wares, such as plates and saucers, and prevent their touching when being burned in the glost-kiln. Spurs differ from pins in having a small conical point which alone comes in contact with the ware. Stilts are triangular bodies with a conical point centrally located on one side and three points at the extremities on the opposite side. They also consist of three arms with double points.

Electrical Porcelain.

Pottery clays are also used in the manufacture of porcelain which is used in electrical works for insulating purposes. Insulating tubes, cleats, buttons and plates and other articles are made of porcelain, which is often subjected to high current and sudden changes of temperature. The body of the ware consists of an admixture of white-burning clay, quartz and feldspar.

Sanitary Ware.

Pottery clays are extensively employed in the manufacture of a long list of hygienic articles, such as wash-bowls, pitchers, lavatory bowls and tops, closet bowls, urinals, bed pans, wash-tubs, sinks, bath-tubs, basins, and soap containers. The body of such ware consists of an admixture of ball clay, kaolin, quartz, and feldspar.

Domestic Ware.

Pottery clays are employed in the manufacture of earthenware, flower pots, and pans; stoneware, jugs, jars, crocks, and churns; white ware and porcelain, table ware; Rockingham and yellow ware, table and cooking ware.

Faience.

Medium or low grade clays are employed in the manufacture of a great many varieties of ornamental wares, which are classed under the head of faience. The articles manufactured cover a wide range of domestic wares and include vases, jardinieres, pedestals, match safes, ash trays, tea sets, steins, pitchers, candle sticks, lamps, umbrella stands, calendars, clocks, picture frames, fern dishes, toilet articles, and ink stands.

Unburned Clay.

Unburned pottery clay is used for various purposes, such as the adulteration of foods and white lead, in the fulling of cloth, in the filling of paper, as a decolorizer of oil, as an absorbent and in the manufacture of soap.

Miscellaneous Uses.

Pottery clays are used in the manufacture of buttons, door knobs, gas burners, fire kindlers, marbles, toy banks, handles for toilet and other articles in imitation pearl, silk spools, smoking-pipes, retorts, mortars, pestles, emery-wheels, caster-wheels, filter tubes, water coolers, condensers, crucibles, shuttle-eyes and thread guides. (See list compiled by Hill and amplified by Ries in Clays.)

CHAPTER II.

THE CHEMISTRY OF CLAYS.

Chemical elements in clay.—The chemical elements composing the minerals commonly present in clay are oxygen, silicon, aluminum, iron, calcium, magnesium, sodium, potassium, titanium, hydrogen, carbon and sulphur. The last two may occur as simple elementary substances uncombined. The other elements are combined to form such compounds as lime, water and silica. In the chemical determination of these elements they are represented as combined with oxygen to form oxides.

TABLE 3.

CHEMICAL COMPONENTS OF CLAY.

Name of Component	*Chemical Symbol*
Silica	SiO_2
Alumina	Al_2O_3
Ferric oxide	Fe_2O_3
Lime	CaO
Magnesia	MgO
Potash	K_2O
Soda	Na_2O
Titanic acid	TiO_2
Sulphur trioxide	SO_3
Carbon dioxide	CO_2
Water	H_2O

Iron, lime, magnesia, potash and soda are classed as fluxing impurities. In clay the lime is usually combined with carbon dioxide (CO_2) to form calcium carbonate ($CaCO_3$), or with water and sulphur trioxide to form hydrous sulphate of lime or gypsum. Other combinations also exist so that an ultimate chemical analysis such as the above does not present, for instance, the amount of gypsum which is present in the clay, but merely the amount of water, lime and sulphur trioxide that is present in the clay. The determination of the percentage of the different mineral compounds in the clay is called its rational analysis. The rational analysis may be computed from the ultimate analysis and is useful in making clay mixtures.

The chemical analysis of a complex substance, such as ordinary clay, may reveal the presence of a large number of chemical elements. Only a limited number of such elements is present in such quantities as to have any influence on the physical properties of the clay.

The following table presents the ultimate analysis of clays belonging to each of the two classes of pottery clays found in the State. They were selected to show the variation in the constituent elements in each group, and between each group.

TABLE 4.

ANALYSES OF SOME MISSISSIPPI POTTERY CLAYS.

Constituent	*Kaolin*		*Stoneware Clays*	
Moisture (H_2O)	.48	1.11	.54	1.51
Volatile matter (CO_2, etc.)	15.01	13.88	7.40	8.07
Silicon dioxide (SiO_2)	44.23	42.92	59.12	61.69
Aluminum oxide (Al_2O_3)	38.82	41.30	27.44	24.91
Iron oxide (Fe_2O_3)	.81	.61	4.39	2.04
Calcium oxide (CaO)	.19	.37	.34	.34
Magnesium oxide (MgO)	.13	.13	.28	.83
Sulphur trioxide (SO_3)	.45	.18	Trace	.20
Total	100.12%	100.57%	99.51%	99.59%

RATIONAL ANALYSIS.

Clay substance	98.21	104.48	69.42	63.02
Free silica	.....	......	17.10	23.58
Fluxing impurities	1.58	1.29	5.01	3.41

In order to determine the amount of clay substance in any of the analyses given in table 4, we may consider all the clay minerals to have the same chemical composition as kaolinite (Al_2O_3, $2SiO_2+2H_2O$). The average composition of some beds of kaolin is very close to the theoretical composition of kaolinite. The latter contains 39.5 per cent of alumina, 46.5 per cent of silica and 14 per cent of water. However, some beds of pure kaolin may exhibit less alumina than is contained in kaolinite. Such would be the case were the predominant mineral cimolite. On the other hand the amount of alumina present might exceed the amount in kaolinite. In this case the predominant mineral might be collyrite or a mixture of some other of the aluminum silicates with gibbsite. The amount of alumina in the first kaolin in the table above given, falls a little below the amount in kaolinite. To obtain the percentage of kaolinite from the ultimate analysis multiply the quantity of alumina (38.82) by the factor 2.53 and the result obtained is 98.21 per cent instead of 100 per cent, as it would have been in the case of pure kaolinite. Now, if the amount of alumina be multiplied by the factor, 1,176, the amount of silica which enters into combination with the alumina to form kaolinite may be obtained. The amount of combined silica is found to be 45.65 per cent. But the total amount of silica is only 44.23, so that there is lacking 1.42 per cent of the silica necessary to combine with the alumina to form kaolinite. Two explanations are relevant. The kaolin may be composed largely of a mineral like collyrite, which is higher in percentage of alumina than kaolinite. Under such conditions there would be some free silica in the kaolin. The same conditions might be brought about as the result of a mixture of these two minerals, collyrite and kaolinite. On the other hand, this composition of the kaolin may be explained by assuming the presence of aluminum oxide (gibbsite) with the aluminum silicate or silicates.

Kaolin No. 2 of table No. 4 contains 1.8 per cent more alumina than is required for kaolinite. It also contains 7.04 per cent less silica than the amount required to satisfy the alumina. Computed as kaolinite, it contains 104.48 per cent. This condition very strongly suggests the presence of gibbsite.

The amount of kaolin in the first stoneware clay of table is 69.42 per cent and the amount of silica is 17.07 per cent.

CHEMICAL COMPOUNDS IN CLAY.

The chemical compounds which are usually included in the ultimate analysis of a clay are the compounds which exert the greatest influence upon the physical properties of clay. For this reason such compounds are of sufficient importance to merit an examination of their form of occurrence in clays, their properties and the effects which their presence may produce upon clay wares. The following pages are devoted therefore, to a discussion of the more important of these compounds.

SILICA.

The silica, the percentages of which are expressed in the analyses of table 4, may be divided, in respect to its influence on the clay, into three parts. The first portion is that which is combined with the alumina to form the kaolin group of minerals. The second portion is combined with other silicates, such as feldspar, hornblende and mica. The third portion is uncombined silica known as free silica or sand.

In making a rational analysis of a clay the last two are rarely separated. The usual method is to compute the amount of silica combined to form kaolinite. This amount called combined silica is deducted from the total amount of silica as revealed by the ultimate analysis and the remainder is called free silica. Ries has pointed out that this method is not entirely satisfactory from the clay workers' standpoint, since some of the silicates have very different properties from the quartz and may exert a very different influence on the clay ware. The effects produced upon clay by the presence of free silica are to influence its texture, its bonding power, its plasticity, its strength, its fusibility and other physical properties. These effects are discussed under physical properties of clay.

ALUMINA.

The alumina revealed by the chemical analysis is derived largely from the kaolin in the clay, but a part may be derived from feldspar and other aluminous minerals. The amount of alumina in the Mississippi clays thus far analyzed, ranges from a few per cent to 41 per cent. Alumina is the most refractory substance found in clays. Besides contributing to the refractoriness of the clay it also furnishes the bonding material for holding together the inert particles. Without its presence the material could not be fashioned into the desired form. Since alumina forms the basis of kaolin or clay substance the amount of alumina present has an important influence on the usefulness of a clay. The amount of alumina in a clay is revealed by the ultimate analysis and is a partial guide to the refractoriness and the plasticity of the clay. Not an infallible guide because there are other factors of plasticity and the presence of other substances may cause a low degree of fusibility even with a high per cent of alumina. The Mississippi kaolins contain from 30 to 42 per cent of alumina and the ball clays from 12 to 25 per cent.

IRON OXIDE.

The amount of iron oxide varies in different clays. It is generally least in kaolins and highest in brick clays. The chief source of iron oxide in clay is from compounds of iron, but a small amount may be derived from ferro-magnesian minerals. The iron compounds, such as hematite, limonite and siderite, may exist either in a finely divided state or as concretions in the clay. Limonite on the application of heat loses its water of crystallization and becomes red oxide of iron. It is to this last compound that the red color of clay wares is due. Siderite, the carbonate of iron, under the influence of heat gives up its carbon dioxide and becomes ferrous oxide. In the presence of oxygen the ferrous iron may be changed to the ferric oxide, the red oxide.

The sulphide of iron may also be reduced to the ferric oxide under the action of heat. Iron is also a fluxing ingredient of clays. When the iron compound is reduced to the ferrous state in the absence of oxygen it will unite with silica forming a ferrous silicate. In the presence of other easily reducible compounds the ferrous silicate may act as a rapid solvent. If there is plenty of oxygen present the ferrous oxide will be further oxidized to the more refractory ferric state. The amount of iron in the Mississippi kaolins seldom exceeds 1 per cent and in the ball clays it is rarely in excess of 3 per cent.

CALCIUM OXIDE (LIME).

The amount of lime in clays is generally below five per cent. Some clays, however, contain as much as 20 per cent. The origin of the lime is from limestone (calcium carbonate) and gypsum (calcium sulphate.) Small amounts of lime may be derived from lime-bearing silicates, some of which are of common occurrence in clays. The effect produced by the presence of lime in clay, will depend on the distribution of the lime and the amount present. Lime concretions may produce cracks or flaws in clay wares, by absorbing water and slaking after the wares are burned. In the presence of iron these concretions may fuse and cause cavities or slaggy masses in the wares. The same amount of lime, finely divided and uniformly distributed through the clay, would have no detrimental effect. However, since lime acts as a flux, its presence in appreciable quantities, tends to lower the fusion point of the clay. For this reason, vitrifying clays should not contain much lime. In the presence of a considerable quantity of iron, the fluxing action of lime may be rapid and effective. With only a small increase of temperature above incipient fusion, the wares may be reduced to a slaggy mass. Lime in considerable quantities in a commonly red-burning clay, may also prevent the development of a red color in the ware. The pottery clays of Mississippi do not contain, as a rule, a high percentage of lime.

MAGNESIA.

The source of magnesia in clay is from magnesium carbonate, from magnesium sulphate, and more rarely from silicates containing magnesium. Dolomite or magnesium limestone is the chief source. This mineral is a calcium-magnesium carbonate (½Ca, ½ Mg, CO). By the decomposition of pyrite in clays, sulphuric acid may be formed. The latter may attack the magnesium carbonate and form magnesium sulphate. The sulphate is soluble in water and if the drainage of the clay bed is perfect, it will cause the sulphate to be carried out by circulating waters. If the sulphate is not separated from the clay, it will be brought to the surface of the ware, either in drying or burning, and produce efflorescence. The action of magnesia under heat, is said to correspond to that of lime, with the exception that at high temperatures the magnesia is not as rapid a fluxing agent as lime. The amount of magnesia in the Mississippi pottery clays rarely exceeds one-half of one per cent, and therefore, exerts little influence upon the clay.

ALKALIES.

The alkalies commonly found in clays are potash (K_2O) and soda (Na_2O). The per cent of alkalies contained in the clays of Mississippi so far determined, is small. Alkalies in clays are commonly derived from silicate mineral, such as feldspar. The compounds of potassium and sodium formed by the breaking down of these complex compounds, are sulphates, carbonates and chlorides. These compounds, being soluble, are removed from the clay under perfect drainage conditions. Imperfectly drained clay beds may contain a considerable amount of these compounds. The alkalies act as powerful fluxes. They fuse at a low temperature, the soluble salts at about red heat. The silicates at higher temperatures. The soda silicates fuse at lower temperatures than the potash silicates. The feldspars are considered an aid to vitrification since they produce a longer period between incipient fusion and complete vitrification. They are detrimental to high degree of refractoriness.

Titanium Dioxide.

The titanium which the chemical analysis of a clay reveals is derived from rutile, TiO_2 and ilmenite, $(Ti\ Fe)_2\ O_3$. Small quantities of titanium will produce a yellow color in kaolin. In large amounts it will give a bluish tint to hard bodies. It is thought, also, to reduce the refractoriness of a clay.

SULPHUR TRIOXIDE.

The sulphur which is present in clay may be derived from a number of sources. It may be from organic matter in the clay, or from gypsum or from sulphide of iron and more rarely from other sources, such as soluble sulphates. When the iron pyrites is heated to a red heat the sulphur is set free and uniting with oxygen, it is expelled from the clay in the form of sulphur trioxide. At a high temperature the sulphur trioxide which is combined with water and lime, to form gypsum, is driven off. The effects of the evolution of this gas is to cause the ware to become porous, if not vitrified, and to cause the ware to swell, if the outer surface of the ware is softened before the gas has all been expelled from the interior of the ware.

CARBON DIOXIDE.

The source of the carbon in clays is the presence of organic matter, of calcium carbonate and magnesium carbonate. The organic matter is consumed during the burning of the clay and the carbon, being converted into carbon dioxide, is expelled as a gas. The calcium carbonate gives up its carbon dioxide and is converted into quick lime at about 90 degrees C. The effect of the expulsion of this gas is to make the body of the clay more porous, unless the burning is carried to the point of vitrification.

WATER (HYDROGEN OXIDE).

The water which exists in air dried clays is either mechanically combined or chemically combined. The mechanically combined water is converted into water vapor and expelled when the clay is heated at a temperature of 100° C. This water must be expelled before the clay ware is subjected to high temperature. For the sudden or rapid conversion of the water into water vapor, will cause bursting of the clay wares. After expelling the water, the clay wares should be kept at a temperature of 100° C or in a dry atmosphere until burned, in order to prevent the water from being absorbed from the air. The amount of mechanically combined water is given in the ultimate analysis under the head of moisture. A part of the chemically combined water in clay, is combined with aluminum and silica, to form kaolinite. There are also other minerals containing water of crystallization, which are of common occurrence in clays. Such for example, as gypsum and limonite. The chemically combined water is usually driven off at a temperature ranging from 400° C to 600° C. The chemically combined water is included under the head of volatile matter in the chemical analysis.

CHAPTER III.

MINERALOGY OF CLAYS.

The minerals composing clays may be classed as essential and non-essential. The determination of essential components will be controlled by the use for which the clay is intended. Iron, for example, is an essential element in any clay intended to be red-burning. On the other hand, it is non-essential and detrimental to a clay intended to be white-burning.

The minerals most commonly found in clay are silica, feldspar, mica, iron compounds, such as hematite, limonite, magnetite, siderite, and pyrite, kaolinite, calcite, gypsum, and hornblende. Others occurring somewhat less commonly are rutile, glauconite, dolomite, garnet and fluorite. Pure clay is a mixture of kaolinite, meershaluminite, halloysite, newtonite, cimolite, pyrophyllite, allophane, collyrite, montmorillonite and schrötterite, silicates of aluminum and gibbsite, an oxide of aluminum. Rock formed of one or more of these minerals is called kaolin. All the other minerals found in clay are termed impurities. The clay compounds and the impurities result from the decay of rocks. For example, granite composed, say, of feldspar, mica, and quartz, may, by decomposition, form allophane, cimolite, kaolinite, biotite, quartz, magnetite, damourite, epidote, gibbsite, muscovite, chlorite, diaspore, limonite, pyrophyllite, newtonite, hematite and hypersthene. Further alteration may result in the formation of other compounds. In the following pages a discussion of the properties of some of the minerals commonly found in clays is given.

KAOLINITE.

Kaolinite (Al_2O_3, $2SiO_2$, $2H_2O$) is an hydrous silicate of aluminum containing 46.5 parts of silica; 39.5 parts of alumina and 14 parts of water. It is a compact friable or mealy mineral, having a greasy feel. It is composed of microscopic scales of crystals which in the aggregate are white in color. It is a soft mineral having a specific gravity of 2.63. Kaolinite results from the decomposition of aluminous minerals, especially the feldspars, one of the common and essential constituents of granites and gneisses It is found in the rocks of all ages, from the Archean to the Recent. Some of the varieties of kaolinite contain more alumina and less water than that in the formula given above. Beds of kaolinite and associate minerals are called kaolin.

In the decomposition of feldspar to form kaolin, the potash and other base are removed by the action of meteoric waters containing carbon dioxide. The residual aluminum silicate takes up water, forming an hydrous aluminum silicate or oxide. The aluminous minerals found in kaolin are here given:

TABLE 5.

ALUMINOUS MINERALS FOUND IN KAOLIN.

	Silica	*Alumina*	*Water*
Kaolinite, $H_4Al_2(SiO_9)$	46.05	39.5	14.0
Meerschaluminite, $_2HAl(SiO_4)+aq$	43.15	41.07	15.78
Halloysite, $H_4Al_2(Si_2O_9)+aq$	43.5	36.9	19.6
Newtonite, $H_8Al_2(Si_2O_{11})+aq$	38.5	32.7	28.8
Cimolite, $H_6Al_4(SiO_3)+aq$	63.4	23.9	12.7
Pyrophyllite, $H_2Al_2(SiO_3)_4$	66.7	28.3	5.0
Allophane, $Al_2(SiO_8)\,5H_2O$	23.8	40.5	35.7
Collyrite, $Al_4(SiO_8)\,9H_2O$	14.1	47.8	38.0
Schrotterite, $Al_4(SiO_8)\,30H_2O$	11.7	53.1	35.2
Gibbsite, $Al_2O_33H_2O$	....	65.4	34.6

These minerals are, rarely, if ever, all found in one deposit of kaolin. Kaolinite is commonly the most abundant mineral in kaolin.

QUARTZ.

Quartz or silica (SiO_2) is usually the most abundant mineral in clays. The composition of silica is silicon, 46.7 parts and oxygen, 53.3 parts. It exists in clay either free or combined. Combined with other substances it forms silicates. The amount of free silica or quartz sand occurring in clay varies from 1 to 50 per cent. The total amount of silica may be much higher, often as much as 70 to 80 per cent. In such clays the percentage of free silica is very high.

The size of the quartz grains in clay is extremely variable. They range from those particles large enough to be removed by screening to those of microscopic size. The grains are transparent, of milky translucence or stained by iron compounds. Quartz grains which have not been transported are usually angular in form. The transported grains have become rounded by the abrasion incurred during transportation. Since quartz is a very hard mineral, being seventh in the scale of hardness, it is not easily broken up, and because of its insolubility, it is not easily decomposed. For these reasons it forms a considerable portion of many sedimentary rocks, and especially of the mantle rock.

Quartz alone is nearly infusible, being fused at cone 35 of the Seger series, a temperature of about 3,326° F. Although of such high refractoriness it may not add to the refractoriness of a clay. Under certain conditions, as when the amount of fluxing material is high, an addition of quartz may raise the fusion point, but such fusing point will be much lower than the fusion point of pure quartz. Quartz added to clay having a low per cent of fluxing material may tend to lower the fusion point of the clay.

The addition of quartz will reduce the shrinkage of the clay. It will also decrease the plasticity, but the amount of reduction will depend on the size of the quartz grains. Clays containing a high percentage of quartz of coarse grains slake more readily than other clays. Clays containing a high percentage of very finely divided quartz slake slowly and are very sticky clays. Quartz of coarse grain adds to the porosity and absorbtion power of a clay. The addition of quartz sand does not necessarily diminish the strength of a clay or of a clay ware. If there is sufficient clay to prevent the contact of the individual sand grains, the clay ware may be stronger for the addition of the quartz sand.

IRON COMPOUNDS.

The element iron may occur in clay in a number of forms. It may be present as a sulphide, an oxide, a carbonate, an hydroxide, a sulphate or a silicate. In the manufacture of some clay wares a limited amount of iron is desirable. For instance, in red ware, such as brick and tiling, the color is dependent on the oxidation of the iron compounds in the clay. A very low per cent of iron is desirable in a clay to be used in the manufacture of white ware of any kind. Some clays burn white, notwithstanding the presence of a large per cent of iron; especially is this true when a considerable portion of carbonate of lime is present. The iron compounds commonly found in clays are limonite, hematite, siderite and pyrite.

Limonite.—Limonite is an hydroxide of iron ($2Fe_2O_3$, $3H_2O$). It contains 59.8 per cent of iron 25.7 per cent of oxygen, and 14.5 per cent of water. As an ore it may occur in rather compact crystalline masses, or as grains mixed with clay, in which form it is called yellow ochre. The yellow or brown color of many clays is caused by the presence of appreciable amounts of limonite. Limonite may occur in clay as a coating for the sand grains, as distributed through the clay in very fine particles, and as large lenticular concretions. It occurs as bog ore in ponds and marshes, having been brought into the water in a soluble form as a sulphate or carbonate, or as some organic salt, through the action of some organic acid. It is precipitated by oxidation and its presence is revealed by an iridescent oil-like film upon the surface of the water. Limonite may result from the alteration of other ores, through the action of atmospheric agents and the presence of organic acids. Through alteration processes it is derived largely from pyrite, magnetite siderite and from silicates, containing iron in the ferrous state. Under the action of carbon dioxide, it may be changed to siderite. By hydration, it may be changed to hematite. It forms the cementing substance for many sandstones and conglomera es. Under the influence of heat, limonite loses its water of crystallization and is changed to the red oxide.

Hematite.—The red oxide of iron (Fe_2O_3) is also a common constituent of clays. The compound contains 70 per cent of iron, and 35 per per cent of oxygen. It is found widely distributed through the rocks of the earth's crust. It occurs in the form of tabular or rhombohedral crystals known as specular iron. In hexagonal plates, it is known as micaceous hematite. In minute particles it is found as a coating for sand grains and is also disseminated in this form through clays and other rocks. It sometimes occurs in clays in concretionary masses. These masses may be coated with limonite, which is formed in the beginning of the process of alteration. In beds of soft rock it forms red ochre. The occurrence of hematite may be due to the alteration of some other iron compound. For instance, pyrite by oxidation, may be changed to hematite. Magnetite and siderite may also be altered to hematite. Silicates, such as hornblende, for example, may be decomposed, producing hematite as one product. Hematite may be altered to magnetite and then changed to siderite by the action of carbon dioxide. When acted on by sulphuretted hydrogen it may form pyrite, or by taking up water it may become limonite.

Siderite.—The carbonate of iron ($FeCO_3$) may occur in clays as minute particles somewhat uniformly distributed and as concretionary masses. Siderite contains 62.1 per cent of iron protoxide and 37.9 per cent of carbon dioxide. It is also found in many sedimentary and metamorphic rocks. In shales and clays it frequently occurs as iron stones, especially in beds associated with coal deposits There are several varieties based on composition. Some of these contain magnesium, others manganese, and still others calcium There are also several varieties as to form. It may be crystalline, earthy, concretionary, granular, compact or oolitic.

Where uniformly distributed through the clay it may give it a slate color. By oxidation siderite may be altered to hematite, to limonite or to magnetite. When present in considerable quantities in a clay, it may act as a flux, causing the clay to be fused at a lower temperature. When heated, it loses its carbon dioxide, and becomes ferrous iron (FeO). The FeO may unite with silica and form a ferrous silicate, FeO_2, $2SiO_2$, which gives to the ware a dark green color.

Pyrite.—Iron pyrites or fool's gold is a bright, brassy mineral, of common occurrence in clays and shales. Its chemical symbol is FeS_2, and its composition is iron 46.6 per cent and sulphur 53.4 per cent. Its common occurrence in clay is in the form of crystals or concretionary nodules of various shapes. Many of these are radiate in structure. In the presence of air and moisture the pyrite (FeS_2) alters to iron sulphate, iron oxide and sulphur. If lime carbonate is present the iron may be changed to the hydroxide and the sulphur trioxide uniting with the calcium may form gypsum ($CaSO_4$, $7H_2O$). Thus by the action of weathering pyrite may be removed from clay. Pyrite may be changed to limonite by oxidation and hydration. By dehydration the limonite may be altered to hematite.

When FeS_2 is subjected to heat the Fe becomes oxidized to FeO and the sulphur is converted into SO_2 or SO_3. At low temperatures the FeS_2 loses S and becomes FeS. At still higher temperatures FeS is changed to FeO and SO_2. In the presence of oxygen the SO_2 may be converted into SO_3.

Marcasite.—Marcasite is a variety of iron disulphide having the same chemical composition as pyrites. It is a common impurity in lignitic clays. Its color is pale bronze-yellow. In clays it frequently occurs in nodules of radiating crystals called "sulphur balls." Atmospheric alteration of marcasite takes place very rapidly. For this reason weathering the clay is one of the most effective means of removing the impurity.

Ilmenite.—The mineral ilmenite, or menaccanite, is an oxide of iron and titanium ($TiFeO_3$) or $(TiFe)_2O_3$). It is an opaque mineral of black or brownish-black color. The normal variety contains 31.6 per cent of titanium, 36.8 per cent of iron, and 31.6 per cent of oxygen. Since this mineral is very refractory and not easily acted on by the agents of decomposition, it is a common constituent of many residual and transported deposits. It also occurs as an original constituent of many igneous rocks. It is sometimes found in tabular crystals, plate like masses or in grains in veins of metamorphic rocks. In many sedimentary rocks it is present in small rounded grains. There are a number of varieties of the mineral distinguished by varying proportions of iron and titaniun. In some species the iron is partly replaced by magnesium. Ilmenite may be altered to leucoxene or titanite.

FELDSPAR.

The feldspars are silicates of aluminum containing calcium potassium, sodium or barium. There are nine principal varieties which are divided crystallographically into two groups: first, the monoclinic feldspars, orthoclase and hyalophane; second, the triclinic feldspars, microcline, anorthoclase, albite, oligioclase, andesine, labradorite and anorthite. The chemical constituents of each of these feldspars is given in the following table from Dana's Mineralogy.

TABLE 6.

CHEMICAL COMPOSITION OF FELDSPARS (DANA).

Species	*Silica* SiO_2	*Alumina* Al_2O_3	*Potash* K_2O	*Soda* Na_2O	*Lime* CaO	*Barium* BaO
Orthoclase	64.7	18.4	16.9	....	....	....
Hyalophane	52.0	22.0	7.0	3.0	1.0	15.0
Microcline	65.0	18.0	17.0	....	....	....
Anorthoclase	66.0	20.0	4.0	7.0	1.0	....
Albite	68.0	20.0	....	12.0	12.0	....
Oligioclase	62.0	24.0	....	9.0	5.0	....
Andesine	57.0	27.0	....	9.0	7.0	....
Labradorite	53.0	30.0	....	4.0	13.0	....
Anorthite	43.0	37.0	....	....	20.0	....

Feldspar is found in crystals in igneous and metamorphic rocks and as grains in some fragmental rocks. It is one of the essential constituents of granite. By the action of carbonate waters on lime and other bases of feldspar, they may be taken into solution and the feldspars decomposed. The decomposition of the feldspar results in the formation of new compounds. These new compounds are aluminous silicates like kaolinite. The decomposition of pyrite may produce sulphuric acid which will aid in the decomposition of feldspar. The decomposition of feldspathic rocks is the original source of clay.

Feldspar is commonly associated with quartz in sand and is, for that reason, a constituent of most clays. Like quartz, it serves to decrease shrinkage in clays, but since it fuses at a much lower temperature, (2,192°F) it may form a chemical union and act as a flux.

CALCITE.

The mineral calcite ($CaCO_3$) is composed of 56 parts of lime (CaO) and 44 parts of carbon dioxide (CO_2). Calcite is the chief constituent of limestone, chalk and marble. It occurs also in marls, shales and sandstones in small grains or crystals. Its presence in sedimentary rocks is largely due to the accumulation of organic remains, and possibly to a less extent, to precipitation from aqueous solutions. There are several varities of calcite. Iceland spar is a clear transparent variety, having the power of double refraction. Dog-tooth spar occurs in crystals, the form of which suggests the name. Aragonite has the same chemical composition as calcite, but differs in its crystallization. Marble or crystalline limestone, is composed largely of calcite. Tufa, travertine and argentite are composed principally of calcium carbonate.

When calcite is heated to a temperature of 1,296° F the CO_2 in composition is driven off and the lime (CaO) remains. On the addition of water the calcium oxide will be changed to calcium hydroxide ($Ca(OH)_2$) with the evolution of heat.

Nearly all clays contain at least small quantities of calcite. The presence of calcite tends to lower the fusion point of the clay. Where present in large quantities or where unevenly distributed it may produce cracking or breaking of the clay product due to the evolution of gas and of heat in slaking. Unless the ware is porous it is possible for the outside of the ware to vitrify before all the gas has been expelled from the inside. This causes a swelling or puffing of the ware.

Many residual clay deposits have been formed by the decomposition of limestones containing clay. The lime carbonate is dissolved by acidulated meteoric waters and carried away, while the insoluble clay is left as a residual product. The amount of clay in the limestone may be exceedingly small, yet in time and under the proper conditions a bed of clay of considerable thickness may accumulate. Such residual clays have been formed in Mississippi by the dissolution of the Selma chalk and of the Vicksburg limestone. Beds of clay so formed usually rest directly upon the surface of the limestone and often contain, especially in the lower portions, nodules of lime carbonate, which represent the more insoluble parts of the limestone. These are often a source of annoyance to the clay worker. They interfere with the moulding and cause flaws in burning. If the bottom clay is used it ought to be crushed so as to distribute the lime through the clay, in which condition it is harmless.

GYPSUM.

Gypsum ($CaSO_4 2H_2O$) is a hydrous sulphate of calcium. It is composed of 32.6 parts of lime and 20.9 parts of water, and 46.5 parts of sulphur trioxide. Gypsum occurs as individual crystals, as crystalline sands, or in massive beds of earthy material. It may be precipitated from sea water under conditions similar to the deposition of common salt. It may also result from the decomposition of pyrite in the presence of lime carbonate. The reactions involved are as follows:

$FeS_2 + 6O = FeSO_4 + SO_2$ or

$FeS_2 + 3O + H_2O = FeSO_4 + H_2S$.

Then $FeSO_4 + 2O + 7H_2O = 2Fe_2O_3\ {}_3H_2O + 4H_2SO_4$.

In the presence of lime

$CaCO_3 + FeSO_4 = CaSO_4 + 2H_2O + FeCO_3$ or

$H_2SO_4 + CaCO_3 = CaSO_4 + H_2O + CO_2$.

There are several varieties of gypsum; the clear, transparent, crystalline kind is called selenite. Satin spar is a fibrous variety with a satin-like lustre. Alabaster is a white, fine-grained variety used in making ornaments. Gypsite is an earthy variety occurring in thick beds of varying purity. Selenite and gypsite both occur in some of the clays of Mississippi. Aggregates of selenite crystals are of common occurrence in the clays of the Jackson group. By the decomposition of pyrite in the Selma chalk the residual clays of that formation contain sufficient gypsum in some localities to cause efflorescence on brick manufactured from the clay. A discussion of the effects of gypsum may be found under lime.

MICA.

Mica is a polysilicate mineral composed of iron, aluminum, calcium, magnesium, manganese and silica. The mica group of minerals contains more than a half dozen important varieties. They are all silicates of aluminum, but vary in other constituents, viz.: potassium, lithium, magnesium and iron. There are two common varieties. The first is a white variety called muscovite. It has the following composition: silica, 45.2 per cent; alumina, 38.5 per cent; potash, 11.8 per cent; and water, 4.5 per cent. The second is a black or dark variety called biotite. Its chemical formula is $(Mg, Fe)_2Al_2Si_3O_{12})$, the potash in the former being replaced by magnesium and iron. One of the most notable physical characters of mica is its perfect cleavage in one direction, permitting it to be separated into very thin plates. It is tough and elastic and has a low degree of hardness.

Mica is an essential constituent of many igneous and metamorphic rocks. When granite and other mica-bearing rocks are decomposed, the crystals of mica are broken up into small thin flakes. These flakes are found abundantly in many residual clays and on account of the low specific gravity of the particles, they are transported long distances and so occur in many beds of transported clay. Mica is an abundant mineral in many of the transported clays of Mississippi. Under the action of weathering agents, these grains of mica may lose their potash and take up water and soda, manganese or lime. Since biotite decomposes more readily than muscovite, it is not found as abundantly in clays as the latter.

The presence of mica in clays desired to be white-burning is detrimental if the clay is to be burned at high temperatures, because of the presence of iron in the mica. As the mica may be fused at high temperatures, it is detrimental to fire clays if present in sufficient quantities.

HORNBLENDE.

Hornblende is a silicate belonging to the amphibole group of bi-silicates. It contains 48.8 parts of silica; 18.8 parts of iron; 13.6 parts of magnesia; 10.2 parts of lime; and 1.1 parts of manganese. Hornblende may occur in crystals, in fibers or in small grains. It is an essential constituent of diorite, and also occurs in other rocks, particularly in some varieties of granite. There are many varieties of the mineral. Actinolite, asbestus, nephrite, and tremolite are light colored varities. Pargasite, beramaskite and black hornblende are varieties of the dark colored amphiboles. While there is a great number of colors, the predominant ones are black, white, green and brown. The mineral is hard and usually exhibits a vitreous or silky lustre. The residual product of the decomposition of hornblende is a clay which contains a high per cent of iron. The iron compounds which may be formed by the decomposition of hornblende are limonite, magnetite, and hematite. Some kaolins which are formed by the decomposition of granite containing hornblende contain iron componuds.

RUTILE.

Rutile is a dioxide of titanium (TiO_2). It contains 60 per cent of titanium and 40 per cent of oxygen. It may contain as much as 10 per cent of iron. Ordinarily it is brownish-red in color and commonly occurs in prismatic crystals. It is a hard mineral, having about the same degree of hardness as glass. Rutile does not commonly occur in clays in other than small quantities. It affects the fusibility of clays and its presence in quantities of as much as 2 per cent may be detrimental to refractoriness. (Ries).

GLAUCONITE.

Glauconite is a mineral occurring very commonly in sedimentary clays of marine deposition. It is a silicate of iron and potassium, containing water. Other minerals such as kaolinite, lime, magnesia and soda, are usually associated with the iron and potassium silicate. Glauconite occurs in clays in grains of a dark green color. Because of the presence of alkalies, it is easily fusible, and therefore, a large quantity is detrimental to the refractoriness of a clay. Glauconite is abundant in some of the Mississippi clays, especially those from the Eutaw.

CHAPTER IV.

THE GEOLOGY OF CLAYS.

Distribution.—Clays are widely distributed both geographically and geologically. Clays were formed as soon as the weathering of the original crust of the earth began. Thus when the first sedimentary rocks were deposited, clays were present. These ancient argillaceous sediments have undergone such profound changes that they have been transformed into slates and schists. So in the rocks of Pre-Paleozoic time, clays do not occur but only their metamorphic representatives. In the beginning of the metamorphic process, the soft beds of clay were compressed and compacted into a firm argillaceous rock called shale. Shales occur in practically all geological formations, from the Pre-Paleozoic to the Quaternary. Unconsolidated clays are common only in the younger formations, where shales are less common. The clays of the Mesozoic era are of great economic importance, particularly those from the Potomac formation of the Atlantic coastal plain and from its equivalent, the Tuscaloosa formation of the Gulf coast plain. In the Gulf states important beds of clay occur also in the Eocene division of the Tertiary.

Practically all of the geological formations of Mississippi contain beds of clay. The Devonian and the Sub-carboniferous contain beds of shale which weather to unconsolidated beds of clay. The Lower Cretaceous contains beds of clay of superior quality. The Upper Cretaceous, while largely calcareous, by decomposition, forms residual deposits of clay. The Tertiary and Quaternary formations are both clay-bearing.

The stratigraphical conditions of clays.—The stratigraphical conditions of clays are varied. In the deposition of clays under marine or lacustrine conditions, if the land is high, or the waters near the shore much disturbed, the beds of clay will be deposited at a considerable distance from the shore. If the land is low, so that no coarse sediments are being yielded, and the waters are comparatively quiet, beds of clay may be deposited near the shore. Clay beds of the latter type are not as likely to be free from coarse particles as the former. The natural

Plate II.

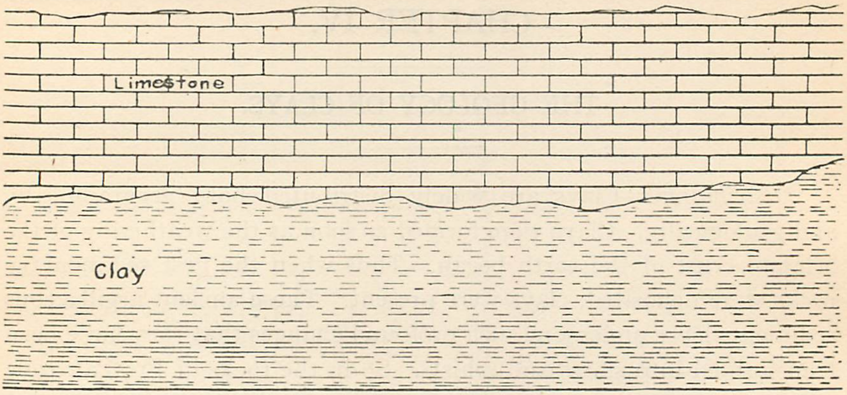


Figure A. BED OF CLAY UNDERLYING LIMESTONE.

order of deposition of sediments upon a sea-floor that is rising, is first, limestone, then clay-sand and last gravel. The last is deposited, provided the bordering land area is high enough to yield coarse sediments.

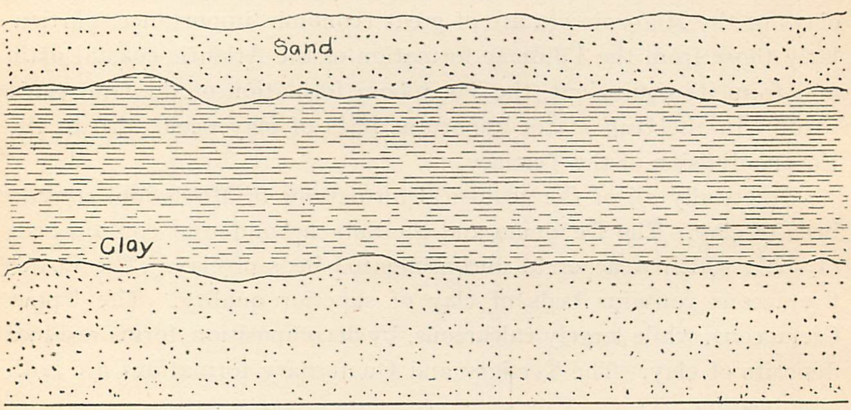


Figure B. BED OF CLAY ENCLOSED BY SAND.

Upon a sinking sea-floor the order of deposition is reversed. But since a cycle of deposition is rarely completed without interruption, the natural sequence is more often the exception than the rule. Thus it is that we find limestones, overlying, underlying or occurring between beds of clay. And thus it is that we find sandstones followed by clays and clays overlying conglomerates.

Clays and shales are very commonly associated with beds of coal. Beds of coal are frequently enclosed by beds of clay or shale.

PLATE III.

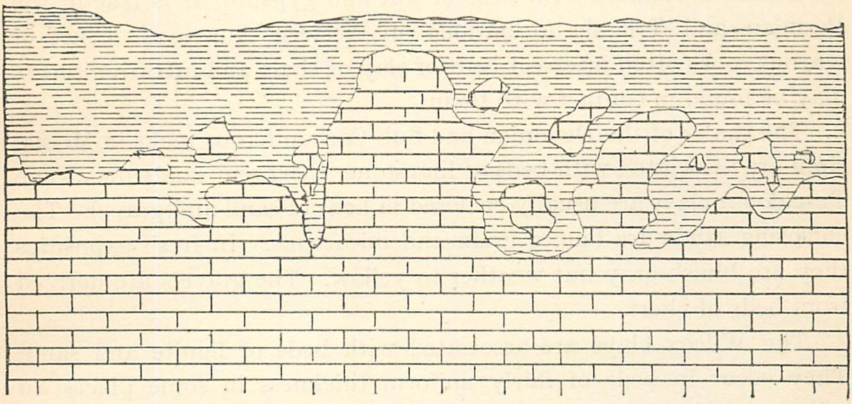


Figure A. RESIDUAL CLAY ON ARGILLACEOUS LIMESTONE.

The clays of Mississippi appear in a number of stratigraphical conditions. The Porter Creek or Flatwood clays occur in a thick bed of fairly uniform texture and extending over a long distance. The white

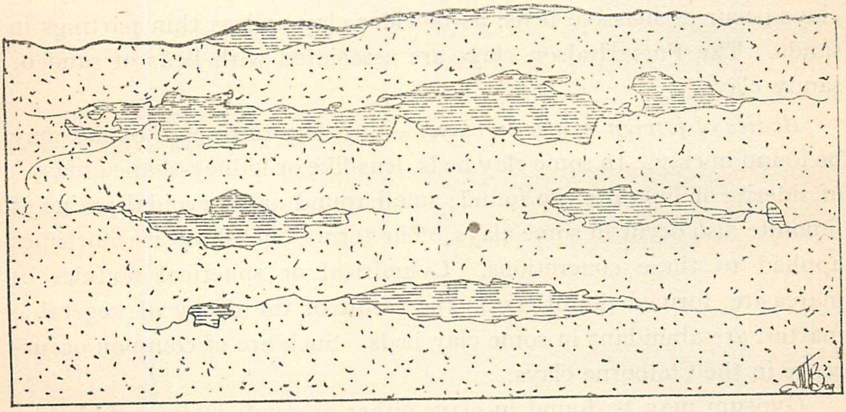


Figure B. CLAY PARTINGS IN SAND.

ball clays of the Wilcox formation are found in lenticular beds enclosed in sand. The Lafayette sands contain thin partings of clay in some places and in others irregular clay bowlders. The clay partings in some outcrops are so thin and wavy as to give the appearance of having been applied by brush or grainer.

Associated rocks.—Clays and shales are found associated with many kinds of rock. In the rocks of the Carboniferous period, limestones, sandstones, shales and beds of coal alternate. Clays and shales are sometimes associated with beds of salt and gypsum, as is true of the Permian and Triassic formations of Western America. Dikes of igneous rocks often intersect beds of clay or shale and intrusive sheets may be found in contact with them.

The shales of the Devonian and Sub-Carboniferous rocks in Mississippi are associated with beds of limestone, chert and sandstone. The Tuscaloosa clays are usually enclosed in beds of sand and gravel. The enclosing sands are fine of grain and micaceous. In fresh exposures they are bluish-gray but weather to yellow. The gravels are derived from beds of chert.

The Wilcox clays are associated with beds of lignite and sand. They occur in beds of fairly uniform thickness in some places, in others as lenticular masses and in still others as thin partings.

The clays of the Jackson formation are associated with the Vicksburg limestone. In some places they are in actual contact, in others, separated by beds of sand and lignite. The Grand Gulf clays are interstratified with sands, sandstones and quartzites. The Lafayette clays occur as massive beds, as bowlder clay and as thin partings in sands. The Port Hudson clays are associated with beds of sand or sandy clays.

Bodies of foreign matter in clays.—A variety of foreign bodies may be found in clay. In some clay beds, lens-like or kidney-shaped masses of siderite or limonite are found; small, round or botryoidal grains of limonite also occur in some clays. The term "buckshot" is sometimes applied to these concretions. Cylindrical or spherical nodules of marcasite, formed doubtless as the result of the decay of vegetable matter, are abundant in some clay beds. Such are of common occurrence in the Claiborne clays.

Gypsum may be found in clays either as small, white, pebble-like concretions or as transparent crystals of selenite. The former are common in some horizons of the Porter's Creek or Flatwoods and the latter in the clays of the Jackson group. Concretions of clay of a great variety of shapes are found in some clays. Some lens-like or spherical clay concretions which have cracked in drying, have had their crevices filled with calcite or other minerals. These forms are called septaria.

PLATE IV.

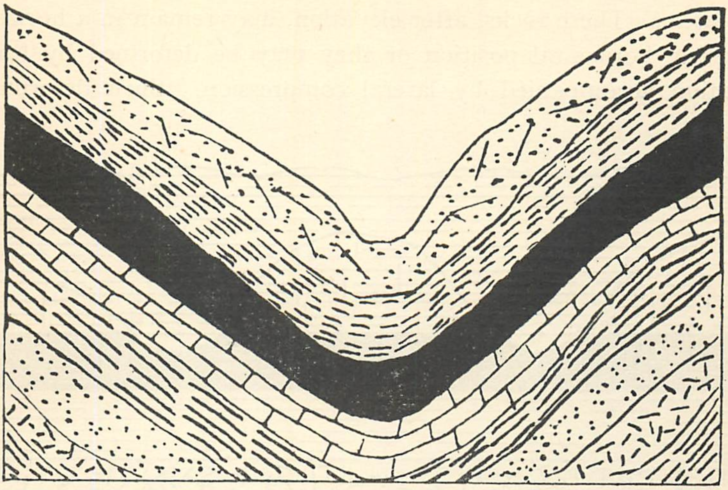


Figure A. A DOWNWARD FOLDING OF ROCKS, A SYNCLINE.

Fossils of both vegetable and animal origin are common in clays. The impressions of leaves are found in the Wilcox and the Grand Gulf clays, the trunks and branches of trees in the Lafayette and the bones of marine animals in the Jackson clays.

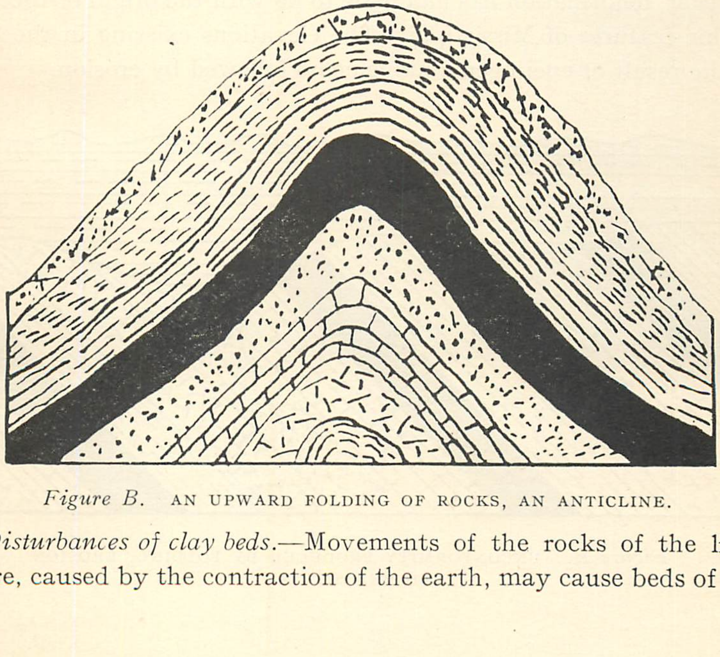


Figure B. AN UPWARD FOLDING OF ROCKS, AN ANTICLINE.

Disturbances of clay beds.—Movements of the rocks of the lithosphere, caused by the contraction of the earth, may cause beds of clay deposited in sub-aqueous areas to be elevated and to become a part of land areas. These rocks, after elevation, may remain in a horizontal or nearly horizontal position or they may be deformed by further elevation accompanied by lateral compression. Such deformation

PLATE V.

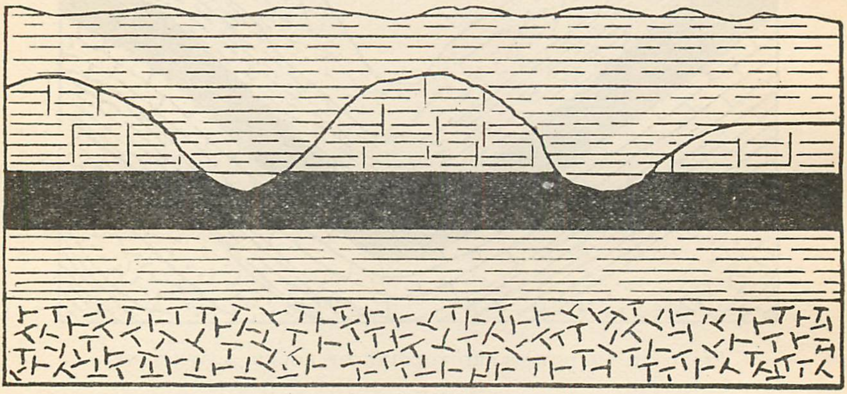


Figure A. AN UNCONFORMITY PRODUCED BY UPLIFT, EROSION AND DEPOSITION.

results in disturbances of the strata known as folding and faulting. However, deformation has had little to do with the origin of the topographic features of Mississippi. The elevations existing in the State are the result of epeirogenic movements followed by erosion.

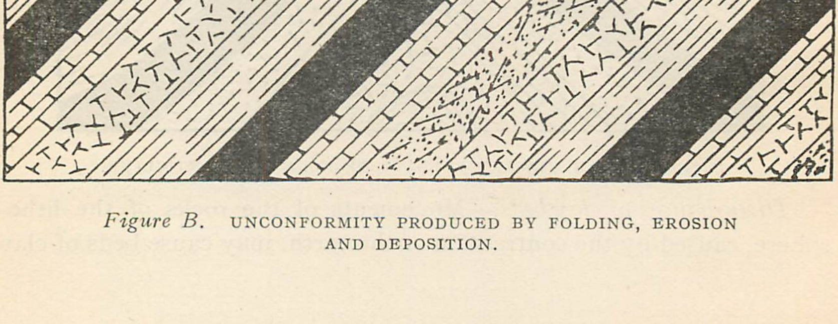


Figure B. UNCONFORMITY PRODUCED BY FOLDING, EROSION AND DEPOSITION.

Faulting.—The rocks of the crust of the earth may be stretched and portions may drop down, thus producing a discordance of the strata known as a normal fault. See Plate VII. If pressure is exerted laterally some of the layers of rock may be thrust over other layers, producing a discordance known as a thrust fault. See Plate VII.

PLATE VI.

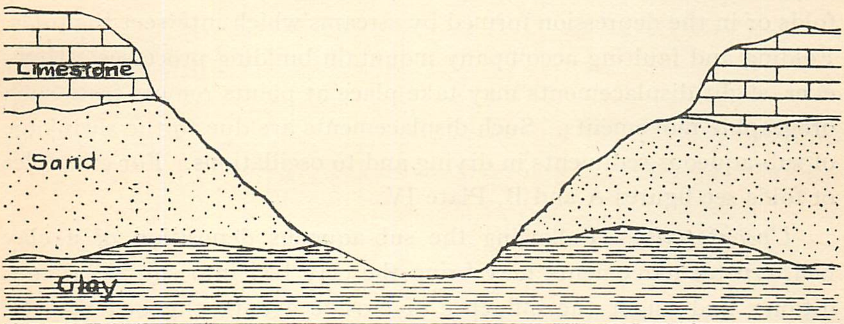


Figure A. SHOWING OUTCROP OF CLAY IN BED OF CREEK.

Normal faults may produce escarpments along the faces of which beds of clay may be exposed. But more extensive exposures may result from the erosion of the escarpment.

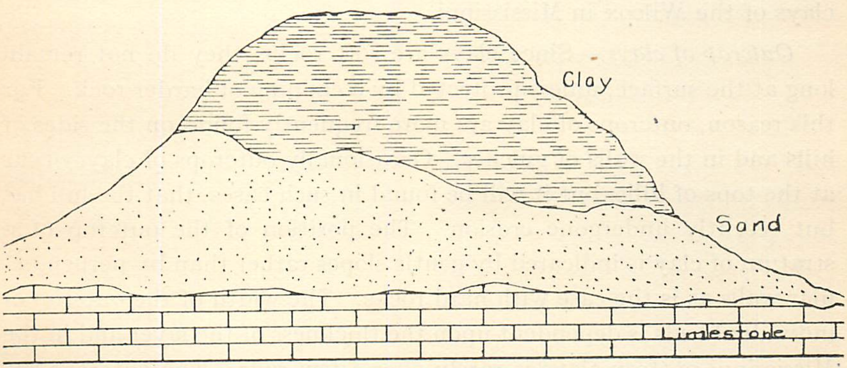


Figure B. CLAY BED OCCUPYING CREST OF HILL.

Folding.—During orographic movements of the crust of the earth beds of rock are subjected to stresses which result in folding of the beds. The strata are bent both upward and downward. The trough-like depressions formed when the rocks are pushed downward are called synclines. The upward bendings of the rocks are called anticlines. These folds may have broad bases with their slopes far apart, or they may have narrow bases with the slopes very near each other. The first are designated as open folds, the latter as closed folds. Anticlines are usually subjected to early and rapid erosion so that the rocks which they contain are soon exposed at the surface. Many beds of clay, as well as other rocks, are exposed on the upturned slopes of such folds or in the depression formed by streams which intersect the folds. Folding and faulting accompany mountain building processes. However, slight displacements may take place at points remote from such orographic movements. Such displacements are due to the shrinkage of sub-aqueous sediments in drying and to oscillations. For examples of folds see figures A and B, Plate IV.

Unconformity.—Following the sub-aqueous deposition of a clay bed, crustal movements may bring the clay bed into sub-aerial conditions, and under the influence of erosive agents the bed may be thinned in places or entirely removed. The surface of the clay bed will now present an uneven appearance and subsequently other beds of rock may be deposited upon this uneven surface, producing a discordance of strata known as an unconformity. Clay beds belonging to the Lafayette are very frequently found lying unconformably upon the clays of the Wilcox in Mississippi.

Outcrop of clays.—Since clays are soft rocks, they do not remain long at the surface, unless protected by a capping of harder rock. For this reason, outcrops of clay are more frequently found on the sides of hills and in the walls of gulches. Occasionally outcrops of clays occur at the tops of hills, but it will be found in such cases, that the hill has but recently undergone erosion. The position of the outcrop of a stratum of clay is indicated by gentle slopes rather than by perpendicular walls as is the case with hard rocks. The width of the outcrop of individual beds is dependent upon the thickness of the layer and in the Mississippi pottery clays is rarely over a few rods. The outcrops are most abundant in deforested areas and along the head-waters of streams in the forest areas. In the Wilcox clay belt, the exposures are not of large area, as a usual thing, although in some recently deforested areas, single outcrops sometimes cover as much as forty or fifty acres. The exposures are commonly made in the small gulches near the head-waters of streams which have their origin in the high lands of the Wilcox area.

The outcrops of the Tuscaloosa clays are also of small area. They

PLATE VII.

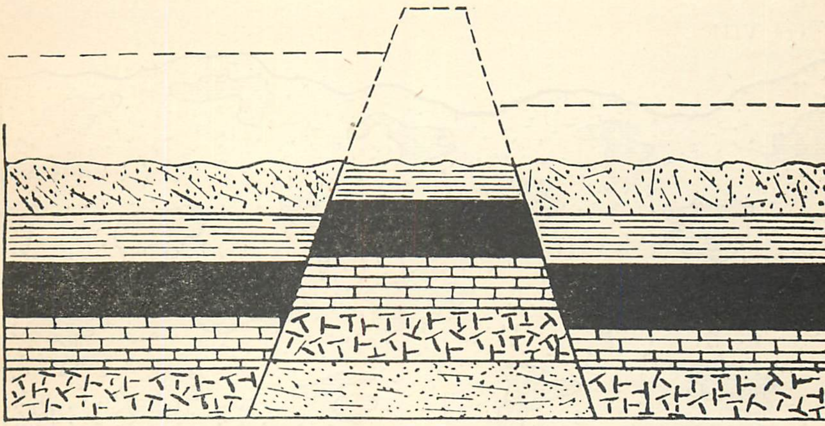


Figure A. DISPLACEMENT OF ROCKS KNOWN AS A NORMAL FAULT. THE SURFACE HAS BEEN ERODED SINCE THE DISPLACEMENT.

occur usually along the courses and near the sources of streams. In the majority of places they have an over-burden of sand or gravel.

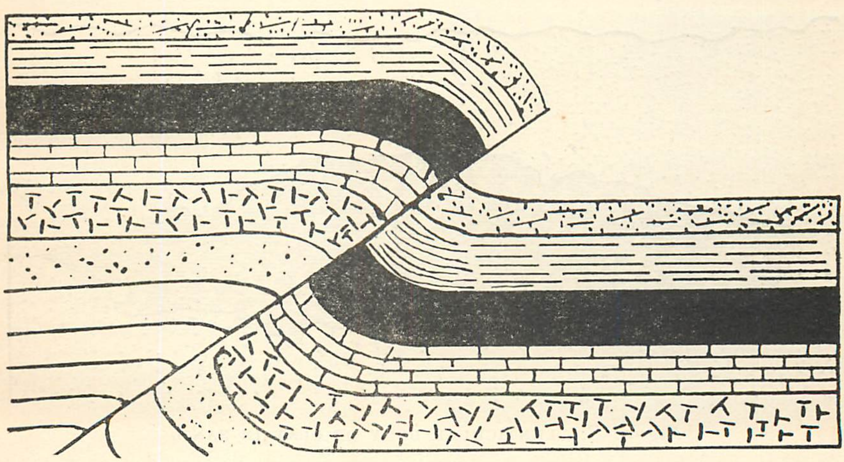


Figure B. DISPLACEMENT IN WHICH THE LAYERS ARE PUSHED OVER EACH OTHER, A THRUST FAULT.

Consolidation of clays.—Beds of clay which are usually deposited as sub-aqueous sediments are soft, incoherent rocks when first deposited. However, other beds of rock may be deposited upon the beds of clay and in the course of time these beds may be subjected to the stresses which accompany crustal movements and the pressure thus

PLATE VIII.

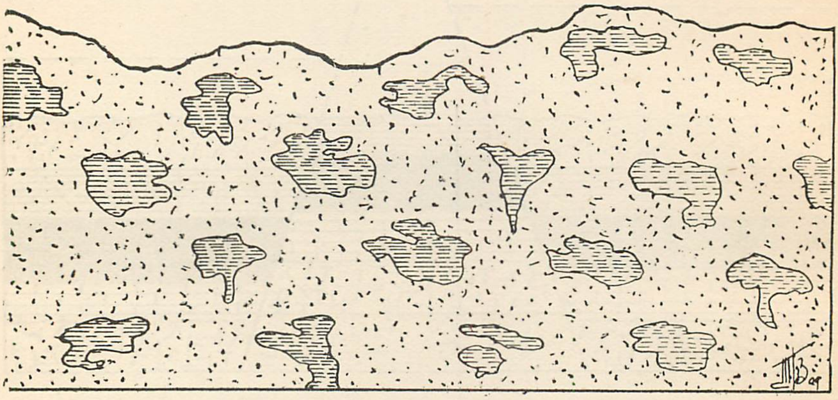


Figure A. CLAY BOWLDERS AND IRREGULAR MASSES IN SAND.

exerted may change the soft clays to more compact harder rocks. As the clay becomes compressed a platy structure may be developed. Such compact, platy clays are called shales. As a rule, shales must

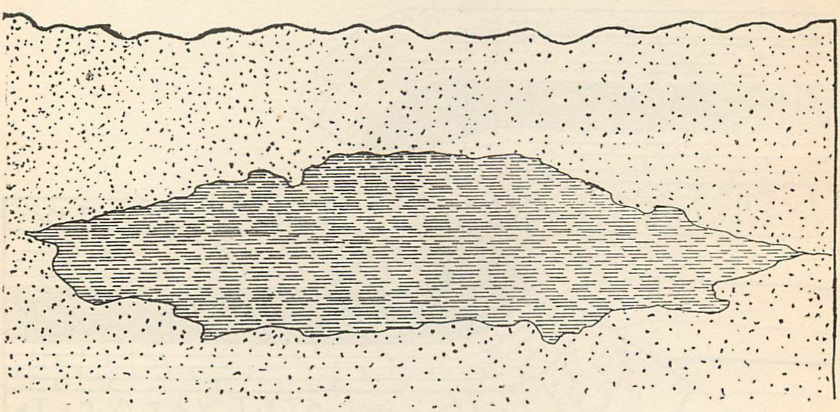


Figure B. LENTICULAR BODY OF CLAY IN SAND.

be pulverized or weathered, before they are suitable for the purposes of the clay worker. They vary much in degree of hardness, composition and color. They are much used in the manufacture of vitrified brick and sewer pipe. Shales are much more abundant in the middle geological periods than in the earlier or later periods. In the rocks of the earlier periods such profound changes have taken place through the lapse of time accompanied by metamorphic processes that the shales and clays in these earlier rocks have been changed to slates and schists. The clays of the later periods have not been subjected to sufficient metamorphism to produce shales.

Prospecting.—The object of prospecting for clay is to determine the location of the clay bed, the quantity of clay present, some facts as to its quality and whether the conditions are favorable for working the bed. Clay being a soft rock, does not, as a rule, remain exposed at the surface but its outcrops become covered with vegetation or are removed by erosion. In prospecting for pottery clays in Mississippi, the prospector should first obtain a geological map of the State, which shows the location of the principal clay belts or areas. Such a map as accompanies this report. By selecting that portion of the area intersected by streams and following their courses the outcrops may be located. The outcrops should be located as convenient as possible to railroad facilities. Having determined by the touch, taste and plasticity, that the rock exposed is clay, the prospector should next determine the quantity. This may be done by making several borings with a small auger through various parts of the bed. Not only the thickness of the bed may be determined, but also its horizontal extension. In order to determine the quality of the clay, either samples must be sent to a ceramics laboratory or to some pottery. The prospector should assure himself of the absence of gravel or other substances which may interfere with the use of the clay for many purposes.

CHAPTER V.

PHYSICAL PROPERTIES OF CLAY.

The physical properties of clay which, from the clay-worker's standpoint, are most valuable are plasticity, strength and refractoriness. Plasticity enables the worker to fashion the clay into the desired form. The strength of the clay permits the clay ware to be handled during the drying and burning processes without danger of breakage. The power of the clay to withstand high temperatures permits it to be burned to a compact, hard body of permanent form. While these are, for the majority of wares, the most important physical properties, there are other properties of very great importance in the manufacture of some wares. The succeeding pages contain brief discussions of the following physical properties of clays: color, odor, feel, taste, hardness, porosity, structure, shrinkage, slaking, plasticity, fusibility, specific gravity, fineness of grain, bonding power and tensile strength.

COLOR.

The color of clays is an exceedingly variable property. Many shades and tints are represented. The color may be due either to the presence of organic matter or to the presence of iron and manganese compounds. Shades of red, buff or brown are generally due to the presence of iron oxides. Blue and dark colors are sometimes caused by the presence of iron carbonate or of organic matter. White clays are devoid of perceptible coloring matter, but some white clays have color developed by burning.

By the color of the raw clay it is not possible to predict the color of the burned product unless the nature of the coloring matter and its amount are known. Some white clays contain enough iron to produce a dark shade when burned in an oxidizing flame. Titanium may produce a purple tint when the clay is burned at a high temperature. Some black clays are found to be very white after burning. The dark coloring matter in many clays is organic matter which is burned out, leaving the product white. Some yellow or red clays containing an excess of iron may burn to an iron black.

The color to which a clay will burn often has an important bearing on its value. A clay which may be of high value as a stoneware clay, because of the presence of coloring matter which would develop dark shades or splotches during burning. The most satisfactory test to determine the color of the burned product is to subject a sample of the clay to the same conditions of temperature to which the proposed ware is to be subjected. The shades of the burned clay are almost as variable as the natural clay.

The oxidation of iron compounds in the clay produces light reds, cherry reds, dark reds, chocolates and iron blacks, the latter being produced by an excessive amount of iron. Clays may contain a considerable quantity of iron and still be white or yellow. Vitrified wares contain iron silicates which may give a green, brown or black color. Spots on white, yellow or red wares are produced by sprinkling the surface of the clay product with iron or manganese particles. The oxidation or reduction of these particles produce black, brown or red specks on the wares.

FEEL.

Clay containing particles of sand is harsh or gritty to the touch. The grit in some clays may be detected by rubbing the clay between the fingers. In other clays the grit can only be detected by moistening the clay between the teeth. Clays having a large percentage of clay base are smooth to the touch. Kaolin is somewhat like talc or soapstone to the touch. It is a very common practice for people to refer to an unctuous clay or shale as a soapstone. These clays may be shaved with a knife to a perfectly smooth surface, while a clay containing grit will have minute pits upon its surface where the blade of the knife has pulled out the sand grains. The moistened surface of the unctuous clay feels greasy or soapy. As a general rule the gritty clays are the least plastic and are called "lean" or "short" clays, while the more unctuous clays are the more plastic and are called "fat" clays. The Mississippi pottery clays are commonly referred to as soapstone when they are blue in color, but are often called chalk if white.

ODOR.

The odor which emanates from the moistened surface of clay is distinct and characteristic. A very similar odor is given by the surface of some minerals when they are rubbed, and they are said to have an argillaceous odor. Some clays containing decaying organic matter have a fetid odor. Some very silicious clays contain such a small amount of clay substance that the argillaceous odor is not distinct. Other clays containing a very high per cent of clay substance do not give off an argillaceous odor. Therefore, this property cannot be counted a safe guide to the amount of clay substance.

HARDNESS.

The property, by virtue of which one mineral is able to scratch another mineral, is called hardness. Clays are soft rocks. They usually range in the scale of hardness from one to three. The maximum degree is attained in the chalk-like kaolin. This property refers to the ease with which the rock may be scratched. The individual particles in a clay may be a great deal harder than the rock. For instance, the quartz would have a hardness of seven, while the feldspar would have a hardness of six. Kaolinite has a hardness varying from 1 to 2.5.

Burnt clay has a much higher degree of hardness than raw clay. Vitrified clay products reach a hardness equal to that of quartz, which will readily scratch glass. Hardness is a property very essential in all clay wares which are to be subjected to abrasion, as are paving brick; or to compression, as are building brick; or to chemical action, as are sewer pipe. Where vitrified clays assume a hardness at which they are untouched by steel.

TASTE.

The presence of ceratin soluble salts in clay may be detected by tasting the clay. Common salt, alum and ferrous sulphate are not infrequently detected in this way. Clay prospectors sometimes place clay between the teeth in order to determine its proportions of sandy matter. They also employ this method to determine the texture and degree of plasticity.

SLAKING.

The crumbling of a clay under the action of water is termed slaking. When a clay slakes it breaks up into small fragments. Slaking takes place wherever an air-dried clay surface is exposed to the action of water. The size of clay fragments or grains into which the clay mass is separated is fairly uniform for the same clay, but varies greatly in different clays. The shape of the particles is variable. Some are flat, some cubical, others irregular. As the particles of the clay separate they absorb water and increase in size.

The speed of slaking varies in different clays. Clays of marked density, such as shale and flint clays, slake very slowly, while the leaner surface clays slake very rapidly. Wet or puddled clays do not slake as rapidly as air-dried clay to which water is suddenly applied. The speed of slaking is determined by taking samples of natural clays of equal size and placing them in water and by observing the time elapsing until they are completely crumbled.

Clays used for any purpose requiring molding without grinding ought to possess at least a moderate slaking speed. A clay possessing a low slaking speed causes loss of time when tempered either in the wet pan or the pug mill. Such clays must be pulverized in the disintergrator and the granulator before they can be tempered and molded. Clays that have been weathered slake more rapidly than when first taken from the pit.

In experimenting with the Mississippi pottery clays it was found that the rate of slaking of a ten-gram cube varies from two minutes to thirty-seven minutes. The rate of slaking of the clays was determined by taking a cube of the clay weighing ten grams just as the clay came from the pit, drying it at a temperature of 100° C. and then submerging the clay in a vessel of water. The time required for the clay to separate into particles was then noted. In order to make sure that the cone of separated particles did not contain an unslaked core a needle point was inserted from time to time into the slaking mass of clay. From these experiments it was found that the majority of the white burning refractory clays slaked in less than ten minutes. The better grade of ball clays slake between ten and twenty minutes. Some of the poorer grades of ball clays required between twenty and thirty minutes for slaking. Those clays which required more than twenty minutes for slaking have been designated in the following pages as slow in rate of slaking. Those clays which slake in from ten to twenty minutes have been classed as rapid, and those which slake in less than ten minutes are classed as very rapid.

SPECIFIC GRAVITY.

The specific gravity of a rock is its weight compared with the weight of an equal volume of distilled water at 60° F. The specific gravity of a substance is obtained by weighing it in air and by weighing it in water and then dividing its weight in air by its loss of weight in water. The specific gravity of clays usually varies from 1.50 to 2.50, but there are some clays whose specific gravity is lower and others whose specific gravity is higher than these limits. Pure kaolin has a specific gravity of from 2.4 to 2.5. Pure quartz sand has a specific gravity of from 2.5 to 2.8. Where clay is largely a mixture of varying proportions of these two minerals, its specific gravity is not far from 2.5. Clays containing in addition to these minerals mica and limonite are slightly heavier. The presence of magnetite, however, may greatly increase the specific gravity, while on the other hand organic matter may decrease it.

Methods of determining specific gravity are not uniform, and different methods may produce different results in the same clay. By the use of the pycnometer the specific gravity of the individual grains is determined and taken as the specific gravity of the clay. By another method the specific gravity of lumps of clay which have been coated with paraffin is determined. This method considers the pore space a part of the clay. The specific gravity of any clay is less by the latter method.

POROSITY.

A porous clay is one which contains considerable space not occupied by clay particles. This unoccupied space is called pore space and its volume depends on the size and shape of the clay particles. The maximum volume of pore space would be attained in a clay containing spherical grains of equal size, but since the shape and size of clay grains are extremely variable this maximum volume is rarely, if ever, attained. The quartz grains in clay are usually well-rounded, water-worn particles. The mica grains are little flat crystals with irregular edges. The feldspar grains are either more or less rounded or irregular. The kaolinite crystals are flat with irregular borders. The grains are in contact only at certain points and thus leaving spaces between the particles. These spaces or pores are in connection with other pores, and a long chain of such connections forms irregular tubes. These tubes are of capillary size, and the water which is within the clay may pass to the surface by capillarity.

Porosity is an important property in clays. The amount of water required for tempering the clay depends in a large measure on its porosity. The air-shrinkage of the clay is brought about by the loss of this water. The speed of tempering and the speed of drying depend on the porosity. The larger the pores the more readily the water is taken up and given off.

STRUCTURE.

The structure of a clay refers to its mode of occurrence in the outcrop or pit. A stratified clay is one which occurs in layers. A massive clay is one in which no division planes are seen. A clay which splits readily in thin leaves or irregular blocks is said to be shaly. If the leaves are small, thin and light the term chaffy is applied to it. A slaty clay is one in which the laminæ have undergone a considerable degree of induration. Instead of occurring in layers some clays are found in concretionary or pebbly masses. Joint clays are those which are separated into blocks by vertical crevices. This structure is an aid to the mining of many clays. These various structures in clay are the result of deposition, compression and induration. In the process of weathering they are obliterated, and the rapidity of such weathering action is often dependent on the structure of the clay. The speed with which a mineral producing soluble salts can be removed by weathering will depend upon the structure of the clay. In order that clay may be used in the formation of clay wares, it must be reduced to a structureless mass. For this purpose it is necessary to employ disintegrating or pulverizing machinery. The expense of this process will be determined by the degree of induration which has taken place in the clay structure.

SHRINKAGE.

The amount which a clay contracts in passing from a plastic condition to that of a rigid solid is termed its shrinkage. The water which is added to the clay in order to render it plastic is lost by evaporation, causing a loss of volume. The loss of volume or shrinkage varies greatly in different clays and with different conditions in the same clay. Water added in excess of the amount required for plasticity will cause a greater loss of volume, as will also the presence of air bodies in the clay. Considerable water may exist in the clay without increasing the volume, but whenever the particles of clay are completely enveloped in water the volume and the plasticity will be increased. Water absorbed by a clay exists either interstitial, *i. e.*, in the pores, or interparticle, *i. e.*, not occupying the pores but causing a separation of the particles. It is the latter which increases the volume of a clay. Clays of coarse grain have large interstices and contain large quantities of interstitial water, but less interparticle water than clays of finer grains; therefore, the fine grain clay shrinks more than the coarse grain.

Air shrinkage.—The amount of contraction which a clay undergoes when drying in the air is called its air shrinkage. The amount of air shrinkage depends mainly on two factors: first, the amount of water absorbed; second, the size of the grain of the clay.

A number of methods of preventing excessive shrinkage is employed. The method more generally in use is that of mixing a sandy clay with the more plastic clay. Under ordinary conditions this is the most economical method. Pure sand and burned clay are sometimes used to decrease shrinkage in clay wares. The air shrinkage of the Mississippi pottery clays was determined by making lines of definite length upon the wet molded brickettes and remeasuring these lines after the brickettes had been dried at 100°C.

Fire shrinkage.—The loss of volume which a clay sustains in passing from the raw to the burned condition is termed its fire shrinkage. In the first stages of burning the clay loses its chemically combined water and the organic matter in the clay is consumed, causing the porosity of the clay to increase. But when the temperature is raised sufficiently high the clay grains soften and run together, destroying the pores and thus causing a loss of volume. Sandy clays not burned to the point of vitrification may not exhibit any fire shrinkage. Clays containing a high percentage of organic matter when subjected to a rapidly increasing temperature may become viscous on the outside, thus preventing the escape of hydrocarbons formed by the distillation of organic matter and therefore cause the ware to increase slightly in volume. A low fire shrinkage is very desirable in pottery clay. In order to obtain the required minimum shrinkage it is necessary frequently for the potter to use a mixture of clays or grog.

FINENESS OF GRAIN.

Clay is a mechanical mixture of mineral particles. These particles vary in size from those which are easily detected by the unaided eye to those which may be seen only by the use of a powerful microscope. The mechanical analysis of a clay consists in the separation of these particles into various groups. But because of the extreme degree of gradation in the size of the particles a complete separation is not possible. Fortunately it is not essential for the purposes of the clay worker. Clay grains are very small, and in the separation of rock particles anything of .001 mm. in diameter or less is classed as clay. The pottery clays of Mississippi contain, as a rule, very little coarse material. Practically all of the clay passes through a screen of 100 meshes to the inch, and only a small per cent of some of the clays is retained on a screen of 150 meshes. For a discussion of methods of mechanical analysis see Bulletin No. 2, The Brick Clays of Mississippi.

PLASTICITY.

A clay is plastic when it can be easily fashioned by the hands into a desired form and when it has the property of retaining that form when so fashioned. Dry clay of any kind is devoid of this property. In order that a clay may become plastic it must be mixed with a certain amount of water. The quantity of water necessary for plasticity varies with the physical condition of the clay. Not all clays become plastic when mixed with water. This fact leads to the conclusion that some clays possess an inherent property which renders them plastic upon the addition of a certain proportion of water. Experience demonstrates that the plasticity of a clay is not due to a single condition, but that it results from the combined action of a group of factors. The factors which seem to have the greatest influence upon the plasticity of clay are the presence of colloidal substances and fineness of grain. It has been demonstrated by various experiments that when colloidal substances are added to clay the plasticity of the clay is increased. It is also a well-known fact that when a plastic clay is subjected to temperatures sufficiently high to destroy the colloidal nature of substances the clay is no longer plastic. It has been demonstrated further that the reduction in the size of the grain of clays has increased their plasticity. Other factors which are thought to influence the plasticity of clay are the presence of combined water, the presence of uncombined water, and the presence of flat and interlocking crystals.

(For a discussion of the causes of plasticity, see the writings of Ries, Orton, Bleininger, Wheeler and others.)

BONDING POWER.

The bonding power of a clay is its power to hold together particles of non-plastic materials. The bonding power of a clay is dependent in a measure on the amount of clay substance which the clay contains. It also depends on the size of the grains of the inert matter added to the clay. As an illustration, a larger amount of finely divided sand may be added to a clay without decreasing its bonding power than of coarse sand. It is often necessary, in order to secure the proper shrinkage and drying capacity in a clay ware, to use a mixture of two clays or to add sand or grog to the clay. The quantity of the inert matter which may be added without seriously impairing the strength of the ware will depend on the bonding power of the clay. Bonding power is a very essential property in all pottery clays.

TENSILE STRENGTH.

The amount of resistance which a clay offers to pull is termed its tensile strength. Wet clays possess this property to a slight degree; dry clays to a greater degree, and burned clays to a still higher degree. Were it not for this property it would be impossible to handle clay ware because of the ease with which they would be cracked or broken. The tensile strength of a clay is not due to any chemical change, but to the physical cohesion of its particles. It was formerly thought that the tensile strength of a clay was a safe guide to plasticity, but it is no longer so, for the reason that many very plastic clays have been found to have a very low tensile strength.

In preparing the pottery clays for the tensile strength test, the clay is first rolled or crushed in a mortar until it is in the condition of a powder. The powdered clay was then passed through a sieve of 100 mesh. To the powdered clay sufficient water was added to render it plastic. The clay was then wedged into blocks about three inches long by one and one-half inches square. These blocks were then placed between the clamps of a Fairbanks' cement mold, the clamps closed and the clay pressed down on the sides until it completely filled the mold. The surplus clay was then stroked off with a putty knife, the surface of which had been moistened. The brickettes were then removed from the molds and placed upon edge. After drying in the air they were placed in a dessicating oven and subjected to a temperature of 100° C. to remove the hydroscopic moisture.

The brickettes were tested by the use of a Fairbanks' cement machine. The brickettes were placed in the clips of the machine and subjected to a gradually increasing tension. The increase of tension is secured by the weight of shot discharging into the pail on the lever arm. At the moment of breaking, the discharge of shot is stopped automatically. If the brickettes have undergone much shrinkage they will not fit the clips of the machine and it will be necessary to bush them. This may be done by placing cardboard or blotter paper between the brickette and the clip.

The tensile strength is expressed in pounds per square inch and the shrinkage was calculated and taken into account in estimating the tensile strength of the brickettes.

In the majority of tests twelve brickettes of raw clay were tested. The average of these twelve tests were taken. The results of these tests are found under the discussion of the physical properties of each clay.

FUSIBILITY.

Matter may exist in three states, viz., solid, liquid or gas. Water, for example, at ordinary temperatures exists as a liquid. At slightly lower temperatures it becomes a solid. At higher temperatures it assumes the form of a gas. When in the solid state, if heat be applied, the solid becomes a liquid. This transformation is termed fusion. The temperature at which the solid becomes liquid is called the fusion point of a substance. The fusion point of any substance is controlled by pressure. All solids, having a definite chemical composition under a fixed pressure, fuse at a certain definite temperature. This definite temperature is called the fusion point.

Ordinary clays, however, are not of definite chemical composition. Clays are composed of a variety of minerals, each having a definite chemical composition and a definite point of fusion. When heat is applied to this aggregate of minerals, the one having the lowest fusion point will be the first to fuse. The molten matter which is free to combine may unite with some other mineral or minerals in the clay and form a compound having a lower fusion point than the original compounds. These when molten may act as fluxes for other minerals and the whole clay be reduced to a molten condition at a temperature considerably lower than the fusion point of its most refractory constituents. The change from the solid to the liquid involves the consumption of heat in raising the temperature of the solid to the fusion point. Some heat is consumed as latent heat, some in chemical reactions.

Three stages are usually recognized in the fusion of a clay, namely, incipient fusion, vitrification and viscosity (Wheeler). In the first stage the more fusible particles become soft and upon cooling cement together the more refractory particles, forming a hard mass. In the second stage the clay particles become soft enough to close up all of the pore spaces so that further shrinkage is impossible. When the mass becomes cool it forms a dense solid body which is glassy on a fractured surface. In the third stage, the clay body becomes so soft as to no longer retain its shape, and flows.

The fusibility of a clay depends on a number of factors, but the most important ones are the amount and kinds of fluxing impurities in the clay and the fineness of the grain.

For determining the temperature of kilns and furnaces and the fusion points of different substances, pyrometers of various kinds are used. One of these is the thermo-electric pyrometer. It consists of a thermo-electric couple which generates an electric current when heated. The intensity of the current increases with the temperature. The current is measured by means of a galvanometer. The thermopile consists of a platinum wire and a wire composed of 90 per cent platinum and 10 per cent of rhodium. These wires, protected by clay tubes, are inserted into the furnace, usually through a small opening in the door.

The fusibility of clays is also determined by the use of Seger cones. These cones are made of a mixture of substances of known fusibility. The cones, together with the clay to be tested, are placed in a furnace or oven and the heat applied. The cone which loses its shape at the moment the clay does determines the fusion point of the clay. For a list of these cones see Bulletin No. 2, Brick Clays of Mississippi, pages 72 and 73.

Many potters use test pieces of the same composition as the body of the ware. The test pieces are often made of the same thickness as the ware and pierced with holes for the insertion of hooks when it is desired to withdraw them from the kiln. They are placed near the outer portion of the kiln and also in the interior. From time to time, after a definite period of firing, a test piece is withdrawn and its hardness tested. Whenever the test piece reaches the degree of hardness desired for the ware the firing ceases. In a good many potteries the test pieces used are the sections of either round or square tubes. On one side of the tube is placed a small amount of Albany slip clay and on the other side a small amount of feldspar. As the fusion point of these two substances are known some idea of the temperature of the kiln at different stages of the firing may be obtained. The tubes also enable one to judge of the progress of the firing by the degree of hardness exhibited.

CHAPTER VI.

MINING, TRANSPORTATION AND STORAGE OF CLAYS.

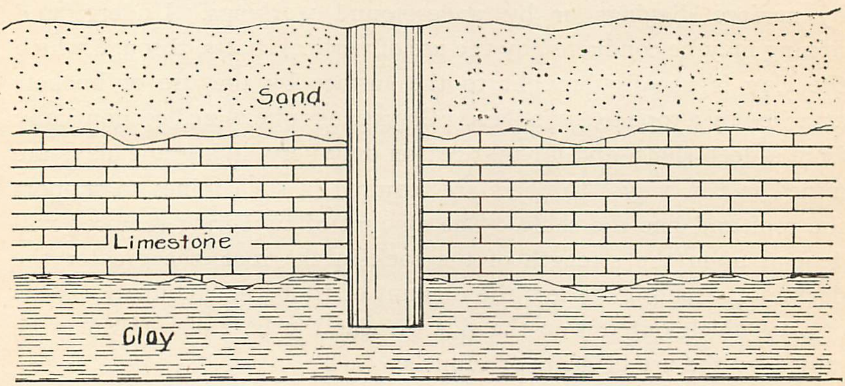
METHODS OF MINING CLAYS.

Methods of mining clays vary with the conditions under which the clays occur. In the mining of indurated clays, such as shales, it may be necessary to use cutting tools, drills and explosives. On the other hand, the mining of soft, incoherent, surface clays may be accomplished by the use of pick and shovel. The mining of clay is carried on either by surface diggings or by underground workings. Underground mining may be conducted by the use of vertical shafts, through which the clay is usually brought to the surface by the use of buckets attached by a rope to a windlass. Clays cannot be mined economically from a deep shaft, and for that reason only very high grade clays are mined in this way. Timbers are required in such mines to support the roof and line the shaft. The amount of timbering required will depend upon the strength of the rock in the roof, the greater the degree of strength the less the amount of timbering required. Beds of clay which outcrop on the side or near the base of a hill may be mined by the use of drifts or tunnels.

The different methods of surface mining may be classed as the (1) pick and shovel method, (2) plow and scraper method, (3) steam shovel method, and (4) rotary digger method.

Pick and shovel method.—Usually the full thickness of the clay is exposed at once by digging a pit to the bottom of the clay bed. A sloping entrance to the pit is left on one side to facilitate hauling. If the clay be uniform in quality it is undermined near the base with a pick, causing the clay above to break off and thus securing the aid of gravity in the prosecution of the work. If there are two or more kinds of clay which it is desirable to mix, the upper layer may be removed for a short distance back, then the lower clay undermined. The two clays are thus kept separate and may be mixed in any desired proportion. In some clay pits nearly every spade length in depth represents a change in quality of clay, so that mining may be conducted on five or six levels. In many surface clays the upper portion of the bed is so sandy that it may be readily mined with the spade, but the bottom clay may be a stiff joint clay which will require the use of pick and shovel.

Plow and scraper method.—The usual method of mining surface clays is by the use of the plow and scraper. The size of the plow and of the scraper, and the number of horses employed, depend on the capacity of the plant. The area of the proposed pit is first plowed and the soil removed. Then it is replowed and the clay taken either directly to the machine or to the mellowing shed, as the case may be, or it is taken to a dump and thrown into a car which is used to transport the clay to a shed or machine.



CLAY UNDERLYING OTHER ROCKS REACHED BY VERTICAL SHAFT.

If the clay be uniform, this process of plowing and scraping may continue until the bottom of the clay stratum is reached. It frequently happens that there is a marked difference in quality between the clay in the top layers and that in the lower layers of the clay stratum. Under these circumstances the best results may be obtained only by mixing the top and bottom clays in certain proportions. In order to secure the proper mixture it may be necessary to remove the top layers from a portion of the pit. This top clay so removed may be placed convenient to the machine or the dump, so that it may be used later and the labor of its removal not wholly lost. The clay is now taken partly from the bottom layers and partly from the top in the proportion to give the best results. Usually the sides of the pit are kept sloping, so that the plow may cross the top clay diagonally, cross the bottom clay near the center of the pit, and pass across the top clay again at the farther side.

Steam shovel method.—In plants of large capacity the steam shovel is employed in mining operations. Its use generally means a great economy in labor. The first cost makes it prohibitive for a plant of small size. To operate the steam shovel a track is laid on the bottom of the pit, and the clay scooped from top to bottom of the wall or face of the pit. The clay pit is usually enlarged in a semi-circle. The track upon which the shovel runs is laid parallel with the periphery and advanced as the wall advances. Inside of the steam shovel track is another track for the cars. When the shovel is loaded, a swinging crane moves it over the car. When in the proper position the bottom of the shovel is opened and the clay emptied into the car. The steam shovel of the dipper type has a radius of action of fifteen feet and greater. A cut is first made for a certain distance, extending to the bottom of the clay stratum. A track is laid upon the surface of the cut, and upon this track the steam shovel is placed. The shovel dips the clay from one bank and delivers it to cars on the opposite side. As the face of the cut advances the track is moved forward and the clay removed from gradually increasing circles. The clay is well mixed, as the shovel takes clay from all parts of the face at each dip.

Rotary digger method.—The rotary clay digger is now used in some surface pits. The digger consists of a steel-frame car which runs upon a track laid on the surface of the ground. At one side of the car is a large wheel which extends downward to the bottom of the pit. The wheel is provided with twelve buckets or scoops which are attached to the rim of the wheel in such a way as to cut into the bank of clay as the wheel revolves. The clay is carried by the buckets to the upper side of the wheel where it is emptied upon an apron which delivers it to a car. The car is placed upon a track which is laid on the bottom of the pit, parallel with the digger track. As the scoops work against the face of the pit they cut the clay from the bottom to the top of the pit. The clay is not only mixed in the digging but also in the delivery. This method of mining is rapid and economical from the labor standpoint, since it requires only one man to operate the machine. However, it can be used only in surface workings where the clay is of uniform quality or where mixing the full thickness of the cut is desirable.

TRANSPORTATION.

A number of methods for the transportation of raw clay from the pit to the machine are employed. These may be classed as (1) wheelbarrow haulage, (2) cart haulage, (3) wagon haulage, (4) scrape-haulage, (5) car haulage.

Wheelbarrow haulage.—Wheelbarrows moved by hand power are employed to a very limited extent in some plants. Usually the plants are of small capacity, and the distances which the clay must be moved very short. Some large plants use wheelbarrows to transport clays from storage bins to pug mills.

Cart haulage.—Hauling clay in a cart is not an uncommon way of transporting clays. The carts are provided with two wheels, and are strongly constructed. They are usually drawn by one mule, though two mules hitched tandem are sometimes employed. The cart is provided with stout shafts and the harness is arranged so that the shafts may be tilted up and the clay dumped out at the rear end of the cart. This saves the labor of shoveling in unloading. The mule is generally driven by a boy who sits on the front endboard of the cart. The clay digger loads the carts, and a man may be employed to dump the carts as they come to the ring pit or pug mill. This method of haulage is not employed for great distances, and only on comparatively level ground.

Wagon haulage.—Two-horse wagons are employed by some brick manufacturers. They are used where the distance from the plant to the pit is considerable and the road rough. This is not an economical form of haulage for a plant of large capacity. Two-horse or four-horse wagons are also employed in transporting clay from railroad cars to the plant.

Scraper haulage.—If the clay used is a surface clay and the pit easily accessible to the machine, two-horse drag scrapers may be employed to move the clay. They are also employed for loading the cars used by many plants.

Wheel scrapers are employed in many dry-press plants, in which it is desirable to store the clay in advance of use. Two horses are employed to draw them. The use of the scraper facilitates the mixing of the clay. It is very frequently desirable to mix a plastic clay and a non-plastic clay. A layer of one kind of clay is spread over the floor of the storing shed. This is covered with a layer of the other kind of clay, and the process repeated until the clay reaches the desired height in the shed. In using the clay, a section is taken from top to bottom of the stored clay. This method makes it possible to secure the proper proportion of each clay, and the mixing becomes more thorough in passing through the machinery.

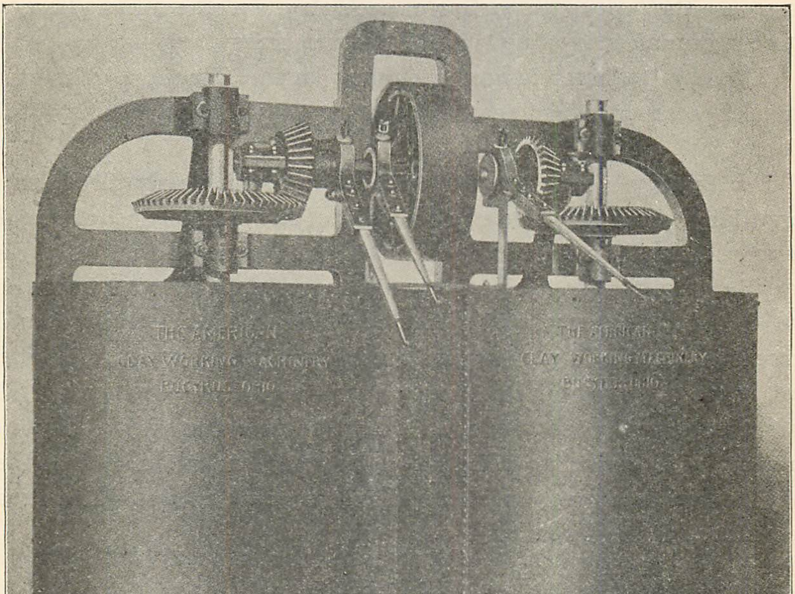
The clay gatherer is used in some plants. This is a cylindrical, wheeled scraper, which gathers the clay and transports it to the plant.

Car haulage.—This form of haulage is used in nearly all plants of large daily capacity. The track consists of two parallel lines of wooden or more often iron rails of light weight laid on cross-ties. The rails vary in weight from twelve to twenty pounds, though it is generally not considered economy to use a rail lighter than twenty pounds, since the car wheels are worn so much more rapidly with the lighter rail. The ties are usually 4 x 4 or 4 x 5, oak or pine pieces. The cars used vary in capacity from one to three cubic yards. Most of the cars now in use have the boxes mounted on pivots so that they may be swung around and dumped from any position. They may be dumped forward, backward or to either side.

STORAGE.

The necessity for storing clays depends upon conditions of the plant with reference to the clay pit and the use for which the clay is intended. Clays which are subjected to preparatory processes in a dry form are stored. Some clays are molded in a dry or semi-dry state, and these require storing during the dry season in order that they may be in condition for use during the wet season. Clays which require transportation over long distances from pit to plant usually require storage at the plant in order that a sufficient quantity may be on hand to meet the daily requirements of the plant. In some plants oblong buildings which parallel the railroad track and are divided into bins are used for storing clay. In some plants the storage is made in a large shed with corrugated iron side walls and roofs. If the weathering of the clay is desirable the clays are placed in open cribs which are very often built of rough hewn logs.

PLATE IX.



BLUNGER MILL.

CHAPTER VII.

METHODS OF PREPARATION AND MANUFACTURE.

GRINDING.

Some clays or shales used in the manufacture of pottery must be pulverized before being used. The dry-pan and the ball-mill are the pulverizers most commonly employed for grinding pottery clays. For a description and cut of the dry-pan the reader may see pages 81 and 92 of Bulletin No. 2. Ball-mills consist of a hollow steel cylinder set in a frame and rotated by means of a driving pulley attached by appropriate gearing to the axis of the cylinder. Clay is placed in the cylinder through an opening in one end. Hard flint pebbles or porcelain balls are placed within until they occupy about one-third of the cylinder's space. As the cylinder is rotated the clay is pulverized by abrasion between the balls and the wall of the cylinder. In the continuous type of ball-mill the clay leaves the cylinder through a perforated plate at one end of the cylinder. In the periodic type none of the clay is removed until it has been completely pulverized. The motion of the cylinder is then stopped and the powdered clay removed. For a cut of a ball-mill see page 91 of Bulletin No. 2.

WEATHERING.

Clays may be used for some purposes without grinding if they have been exposed to the weather sufficiently long to soften them. Some clays are weathered and then ground; others are either weathered or ground only. Clays which are used in the manufacture of earthenware or stoneware are used very frequently just as they are taken from the pit, but in most instances it is found to be of advantage to weather them. Pottery clays are sometimes stored in uncovered bins at the pit and exposed for a period of time to the natural elements. Again they are hauled to the pottery, stored in uncovered bins and watered from time to time to facilitate weathering. Clays used in the manufacture of Rockingham and yellow ware are usually so weathered before being blunged. Weathering not only renders the clay more plastic but also causes the oxidation of deleterious substances such, for instance, as iron pyrites.

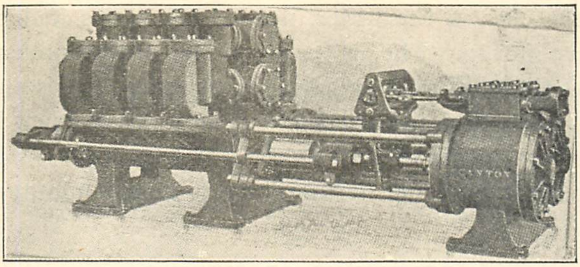
WASHING.

Pottery clays intended for use in the high grade wares are first washed in order to remove gravel, sand and water soluble material. The soluble impurities are easily and completely removed by washing. The complete removal of the insoluble materials is attended with grave difficulties. Since washing is an expensive process, for that reason it is not employed for low grade clays. Clays of open texture may be washed as they are taken from the pit, but close textured clays must first be ground. In the process of washing, the clays are usually put into circular vats or tanks with water and the mixture agitated either by hand or by machinery. The process is similar to blunging, and blungers may be used. From the blunger the water containing the particles of clay in suspension is drawn off through an opening placed a short distance above the bottom of the tank. The coarser particles settle to the bottom of the tank, where they are removed from time to time. The liquid clay is drawn into settling tanks. The number of tanks employed depends upon the desired degree of purity of the clay and upon the desired amount of clay. If a very pure clay is desired the clay is passed through several tanks. It is allowed to stand a while in one tank and is then drawn into another, and so on, the purer clay settling in the last tank. After the suspended particles of clay have settled in the last tank the water is drawn off. The clay may be removed by shovel when it has dried a little, or it may be agitated with water and sent through the filter-press.

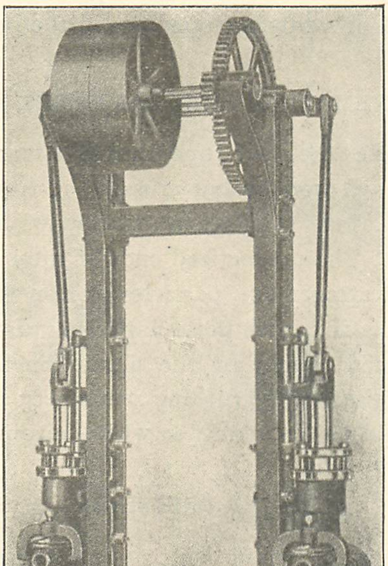
BLUNGING.

The blunger (Plate IX) is a tank usually about five feet in diameter containing a vertical shaft to which are attached two beater arms. To these arms two grill-like beaters or stirrers, made of iron, are attached. The metallic shell is made of one-fourth inch steel boiler plate. It is lined either with corrugated iron plates or with bricks. Motion is conveyed to the blunger by gearing attached to a horizontal shaft, to which several blungers may be attached. The clay and other

PLATE X.



A. PRESS FILLER AND SLURRY HUMP.



B. SLIP PUMP.

materials are placed in the tank, and water is added. The revolving arms mix the clay in the water, destroy all lumps and reduce the mixture to a thin slip. The proper proportion of water must be added in order that the mixture may have the necessary consistency to prevent the separation of the particles. The mixture must be in constant agitation in order to prevent the particles from settling. The time required for blunging is from forty to ninety minutes.

SCREENING OR SIFTING.

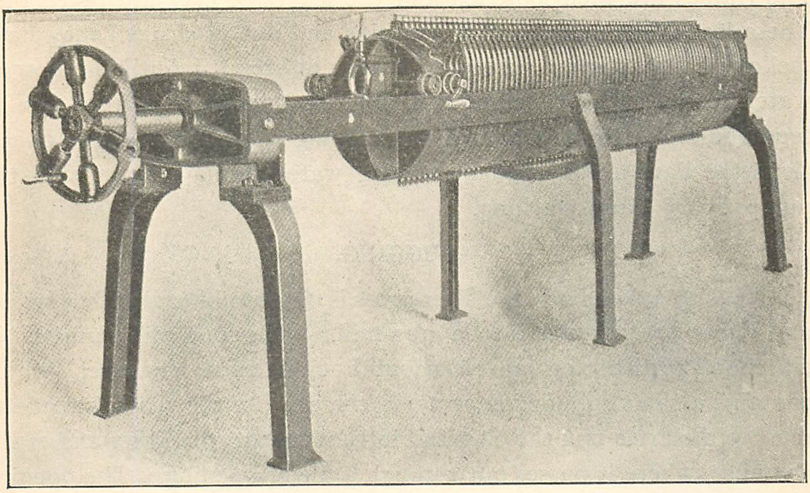
The liquid clay as it comes from the blunger is allowed to pass through a fine sieve. The sieve is usually made of silk lawn of 100 to 150 meshes to the inch, though wire sieves are sometimes employed. Particles in the slip which are too large to pass through the sieve are caught on the upper surface, which is inclined toward a small trough. A vibratory movement of the sieve frame jars these particles off the inclined surface and prevents the openings in the screen from becoming clogged.

REMOVING IRON PARTICLES.

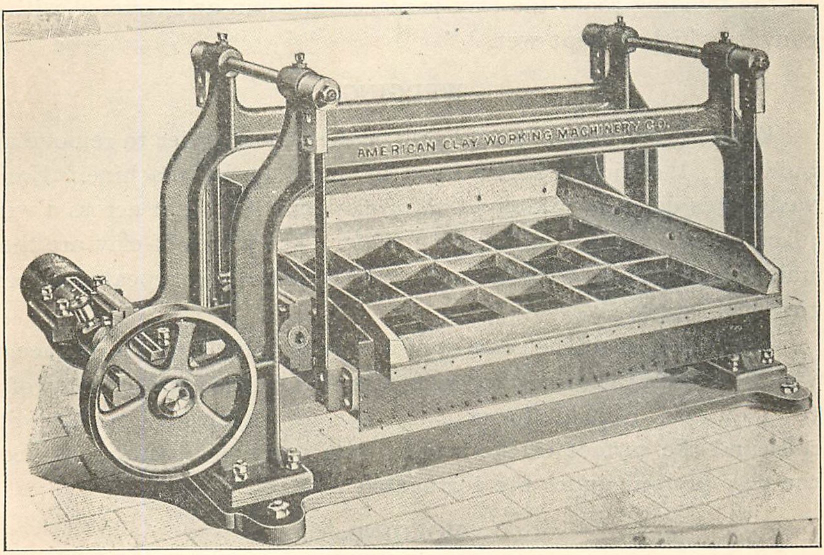
The slip as it leaves the sieve runs through a wooden trough into a cistern or agitator. A wooden bar crosses the trough lengthwise at its upper surface. Along this bar are suspended a number of large horseshoe magnets. The magnetized ends of these extend down into the liquid clay and attract any particles of iron which may be suspended in the clay. Of course these particles must be very small or they would have been caught by the sieve. Such particles of iron may have their origin in the crushing machinery or in the blunger. Their presence would be disastrous to white-burning ware.

FILTER-PRESSING.

From the agitator the liquid clay is pumped into the filter-press. The style of pump used is shown in Plate X and the filter-press in Plate XI. The filter-press consists of an iron frame between the compartments of which are placed flat canvas bags. The liquid clay is forced into the bags through a central opening and the pressure produced by the pumps forces the water out through the bags. The water then escapes through grooves and openings in the iron discs.



A. FILTER PRESS.



B. SHAKING SCREEN.

The frames are then loosened and the leaves of clay are taken out. These leaves are usually stored in bins and not used until they have mellowed for a time. The pumps are not stopped until the flow of water ceases. The time required for one operation is from two to four hours. After a period of use varying from one to three operations the bags are washed by forcing water through them with the pump or by hand washing.

PUGGING.

The clay taken from the filter-press is cut into blocks with a spade, and these are thrown into a pug-mill. The pug-mill consists of either a vertical or an horizontal cylindrical chamber which contains a shaft supporting arms or knives. As the shaft is made to revolve the arms mix the clay and force it toward the lower end of the chamber, where it passes out through a die or opening. The opening is made either round or square, and so the clay column which issues is either round or square in cross section. As the column of clay issues from the pug-mill it is cut into sections having a length of about eighteen inches. These sections are placed on carriers fastened to an endless belt elevator. This elevator raises them to the molding room. In the molding room the clay is placed in a bin and covered with a canvas, which is kept wet.

WEDGING.

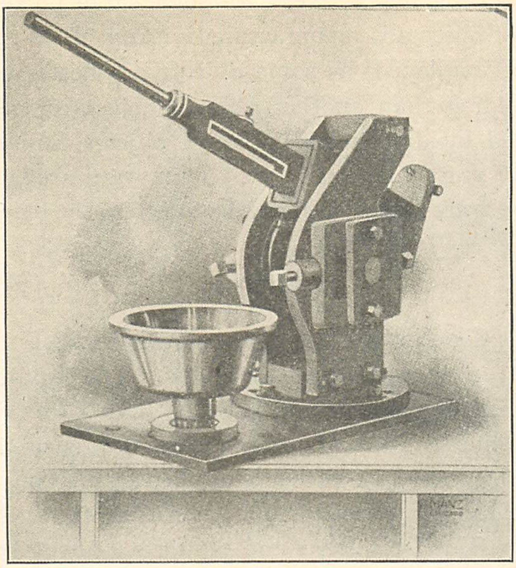
Wedging consists of a kneading of the clay in order to remove air bubbles. Wedging may be done by hand or by machine. Hand wedging is done by taking a ball of clay and cutting it across a wire placed over a plaster surface on a table. The pieces of clay are then united and kneaded with the hands, and the process is repeated several times.

The edging machine consists of a circular table over the surface of which two conical corrugated rolls attached to the opposite ends of a common axis are made to revolve. The clay is kneaded between the rolls and the surface of the table. Two pairs of vertical rolls keep the clay pressed under the corrugated rolls.

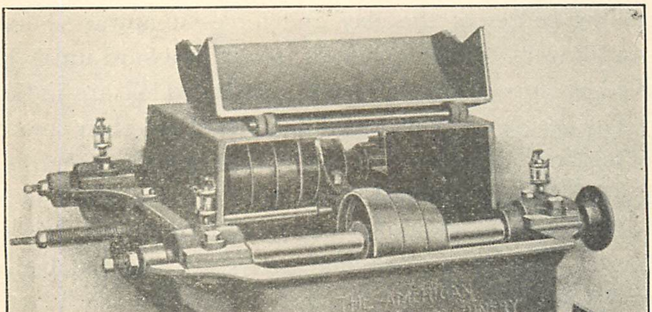
MOLDING.

The formation of the ware may be accomplished by any one of a number of processes, viz., throwing (turning), jollying or jiggering,

PLATE XII.



A. BENCH JOLLY.



B. BENCH LATHE.

casting and pressing dry or wet. In some large potteries where a great variety of objects is manufactured, nearly all of these methods of molding are employed, as some objects are better suited to one method of molding than another. Small objects of certain shapes are best molded by dry pressing. Large objects cannot be molded in this way, but must be molded wet. Thin wares are best formed by casting. Some wares may be formed more rapidly by jollying than by throwing.

THROWING.

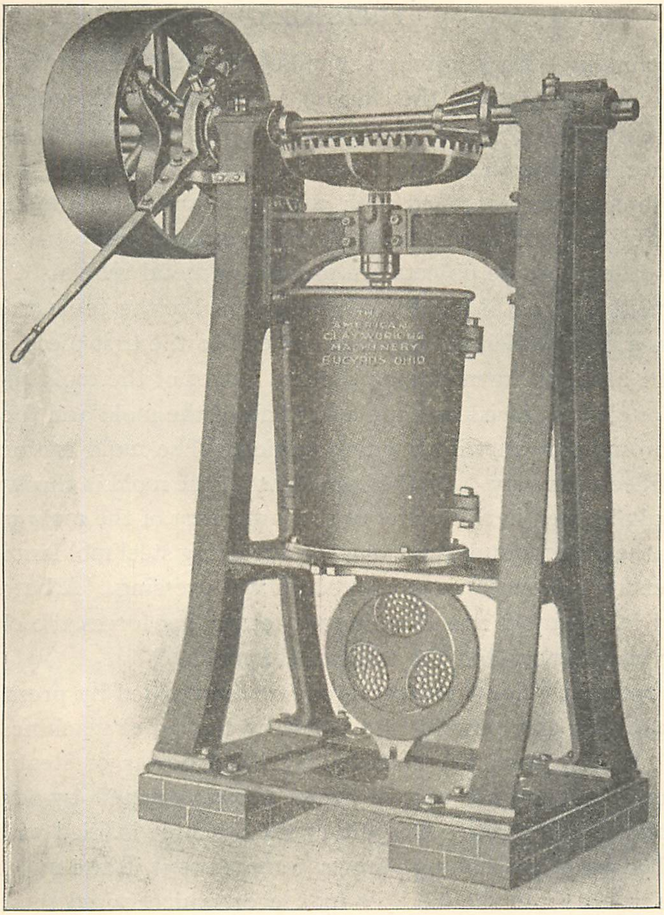
Throwing is done by the use of the potter's wheel. The potter's wheel was used in times of great antiquity. The Egyptians revered it as an invention of the gods and believed that Num fashioned man upon it. The simplest form of potter's wheel now in use is the "kick" wheel, so called because the power is applied by moving a lever with the foot. The lever is attached to a vertical shaft which is fastened pivotally to the floor by a collar and supports a heavy balance wheel and the upper end of which is mounted by an horizontal disc. In all large plants these wheels are now turned by machinery furnished with steam or electric power.

In the formation of ware upon a potter's wheel the potter takes a ball of kneaded clay, sets the wheel in motion and places the clay on the center of the rotating disc. He then presses his thumbs downward into the center of the clay and forces it upward between his thumbs and fingers. The clay is also forced outward until the vessel has reached its proper diameter and height, which are indicated by gauges. The inside and outside of the vessel are then smoothed by the use of leather and sponge. The object is then cut from the surface of the disc by passing a small wire across the disc while it is yet in motion. If the object is small it may be lifted from the disc by hand, if it is large a pair of semi-circular lifters are inserted beneath the object for lifting it.

JOLLYING OR JIGGERING.

The jolly consists of a hollow head attached to a vertical axis which is rotated in the same way as the wheel. Into the hollow head is placed a plaster mold of the object to be formed. A ball of clay is then placed in the mold and is pressed against the sides with the hands as the head revolves. For forcing the clay uniformly against the mold and smoothing the interior of the object a tool attached to the arm of a "pull-down" is brought within the mold. The tool not only

PLATE XIII.



WAD MILL.

smoothes the interior, but also gives the walls their proper thickness by removing surplus clay. Cups, nappies and similar objects are molded in this way. The process for flat ware, such as plates, differs slightly. The clay is first batted out on a kneading table with a plaster maul. The surface of the bat is smoothed by the use of a thin broad-bladed knife. The smooth side of the bat is then placed on the mold, which is made to represent the inside of the object. A smoothing tool is then brought down and forms the outside of the object. The edges are trimmed by a knife in the hands of the jigger-man.

PRESSING.

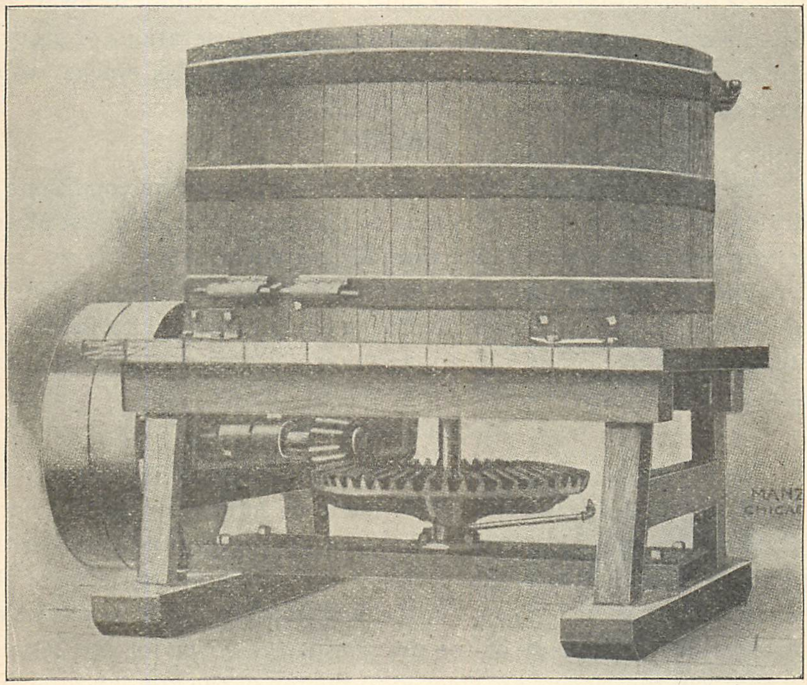
Wet pressing.—Cups, pitchers, handles and other objects are sometimes molded by pressing the clay by hand into plaster molds. The molds are made in sections, and a bat of clay is pressed into each section and the sections are then put together. The inside seams of hollow objects are smoothed with a sponge, and after the clay has partly dried the molds are removed and the outside seams trimmed off and smoothed. Some objects are pressed in metal molds. One-half of the mold is in a thick piece of iron fastened to the table, the other half is in a piece which is hinged at one end to the first piece, so that it may be brought down placing the two halves of the mold together. A piece of clay is placed into the lower half of the mold and the upper half is brought down with a quick motion. The mold is thus completely filled with clay. As the upper part of the mold is thrown back a small pin located in the center of the lower part of the mold is raised and lifts the object out of the mold. A revolving steel mold into which a plunger fits is sometimes employed for wet pressing. A bat of clay is placed in the mold and the plunger descending forces the clay out between the plunger and the walls of the mold.

Dry pressing.—Some pottery products are molded by pressing the dry or semi-dry clay powder into molds by the aid of machines called presses. Such presses are operated by hand power or steam. The hand power presses are of two types, those operated by lever and those operated by screw. The die of the machine is filled with powdered clay and a descending plunger compresses it in the mold. The object is raised from the die by a foot lever, which raised the bottom of the die on a level with the surface of the table.

CASTING.

The clay is mixed with water to form a slip, which is then poured into plaster molds. As the porous plaster absorbs the water the clay is deposited on the inside of the mold. When the proper thickness of clay has been obtained the remaining slip is poured out. After the clay in the mold is sufficiently dry the mold is removed. Objects with very thin walls may be obtained by casting. Very plastic clay bodies cannot be used for casting as the first layer becomes impermeable and no more clay can be deposited. Care must be exercised in pouring the slip into the mold to prevent the inclusion of air bubbles. For thick pieces two or three pourings are made.

PLATE XIV.



GLAZE MILL.

TURNING.

Some objects after being molded are turned on a lathe. The object of turning is to reduce the ware to a uniform size and thickness of wall. The article to be turned is attached to a wooden head either by being stuck on, or if it be hollowware, by enclosing the head piece. As the object turns with the lathe sharp tools are held by the turner against the surface of the object and it is thus reduced to the proper size and shape. Such objects as vases, cups, handles and legs for lavatories are turned. Not as much of the common domestic ware is turned now as formerly.

FINISHING.

Finishing may be done on the lathe after the object has been turned when the operation consists in merely smoothing the surface. This is usually done by holding a piece of horn to the rotating body or applying a damp sponge to its surface. Objects which have been formed of two or more pieces by pressing must have their seams cut away and the surface smoothed. Other objects require perforations or grooves cut in the body, and still others, have defects, such as cracks, which must be repaired.

DRYING.

As pottery products require slow and fairly uniform conditions of drying, in order that cracking may be prevented, they are first placed in an open room which is free from air currents. After having dried for a period of time they are then placed in the dry-room, called the greenware room. In this room the ware is subjected to heat from stem coils or ovens and the drying takes place more rapidly without danger of cracking.

BISCUIT BURNING.

The dry ware is taken from the drying room and placed in saggers, which are oval or circular vessels made of refractory clay. Coarse white sand is sprinkled on the bottom of the saggers and between the pieces of ware. A wad of soft clay is laid along the top edge of the sagger and when it is placed in the kiln another sagger is placed on top so that the bottom of the first forms the cover for the second. In this way the saggers are stacked to the top of the kiln, and the kiln is filled with columns of saggers loaded with ware. The door of the kiln is now closed and the temperature of the kiln gradually raised until it reaches that degree necessary for the burning of the ware. The temperature of the kiln is determined by the use of cones, test pieces or pyrometers, which are inserted in the kiln through small apertures which are placed in the walls of the kiln at different levels. The fuel used is gas or coal.

The ware in the kiln is allowed to cool gradually before being removed.

BRUSHING.

After the biscuit ware has been removed from the saggers it is then brushed in order to remove any particles of sand or other substances which may be sticking to its surface. Brushing may be done by hand or by machine. The brushing machines have revolving circular brushes with their bristle surfaces brought together. The biscuit ware is passed between these brushes. These machines are used mostly for flat ware. Deep ware is still more commonly brushed by hand, though it is possible to use the machine with special forms of brushes.

UNDER GLAZE DECORATING.

If the ware is to receive any form of decoration under the glaze it is taken, after brushing, to the decorating room, and the decoration applied to the biscuit. The decoration may be painted with a brush, may be put on with a stamp or may be transferred from printed paper. The methods of decoration will be described more completely under the subject of over glaze decorating.

GLAZING.

The biscuit ware is now taken from the brushing room or the decorating room, as the case may be, to the glazing room, where it is dipped in vats of glaze in the form of a slip, which may be made of natural clay or of a mixture of mineral compounds. Instead of dipping the glaze may be added by using a spray. Two kinds of glaze may be placed on the same object. The lower portion of the object may be treated with a transparent glaze and the upper portion with an opaque glaze.

GLOST BURNING.

After drying the glazed ware is put into saggers for the glost kiln. In the saggers the different pieces of ware must not be allowed to touch each other or the walls of the sagger. To support flat ware small triangular pieces of clay called sagger pins are inserted in depressions in the walls of the saggers, and the pieces rest on the points of these. Other objects are supported by spurs which are small triangular pieces of clay with conical points, the latter alone coming in contact with the ware. Deep objects are separated by the use of stilts, which are made with two sets of conical points extending in opposite directions. The saggers are stacked in the glost kiln as in the biscuit kiln. The temperature to which the kiln must be raised depends upon the point of fusion of the glaze. It may vary from cone 07 to cone 13.

DRESSING.

When the ware is taken from the saggers in the glost kiln it is taken to the dressing room. Here the marks made on the surface of the ware by the pins, spurs and stilts are removed by striking the little projections with edge of a sharp steel chisel.

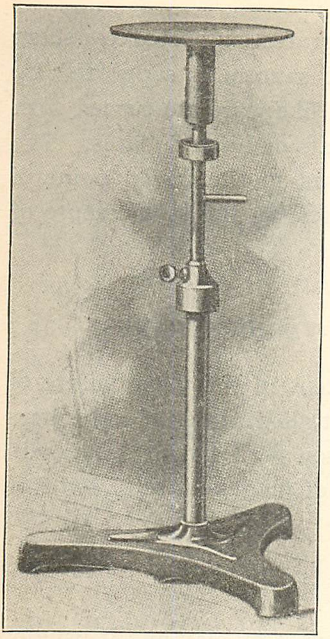
OVER GLAZE DECORATING.

Objects which are to receive over glaze decoration are taken from the dressing room to the decorating room. The over glaze decoration may be applied by brush, stamp, print, sponge or spray. Gold decoration is applied commonly by brush, but some designs are stamped with a rubber stamp, and stipple work is added with a sponge. Tinting is done by means of a spray. The liquid coloring matter is forced upon the surface of the ware by compressed air. Shading is accomplished by varying the amount of spray. Colored figures and designs, such as flowers, are painted with brush or transferred from printed paper. In the latter process the design is first engraved on a copper plate. The copper plate is used as a die for printing the colors on a special paper which receives its impression in a printing press. The surface of the object to be decorated is covered with a special varnish (size) and the paper is placed printed side down upon the varnished surface. The paper is then dampened and removed while the colored design remains upon the surface of the varnished ware. The varnish is volatilized, leaving the colors to unite with the glaze. Objects to be decorated by the use of the brush are placed upon a whirler (Plate XV) so that they may be turned with ease.

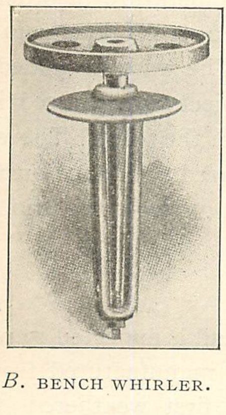
DECORATION FIRING.

After the over glaze decoration has been placed on the ware it must be fired in the decorating kiln in order to fix the colors. The decorating kilns are small, narrow muffle ovens, two to each stack.

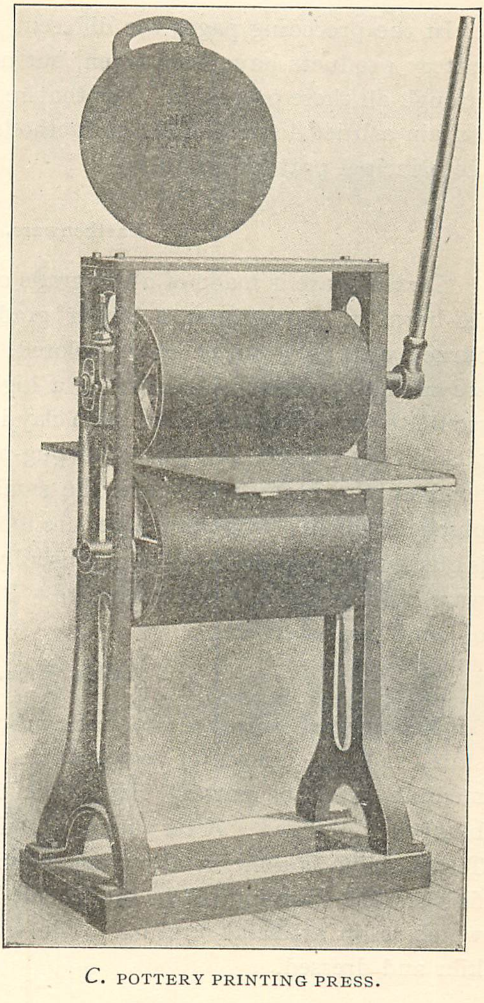
PLATE XV



A. DECORATING WHIRLER.



B. BENCH WHIRLER.



C. POTTERY PRINTING PRESS.

The ware is placed in the kilns on iron grates supported by short iron supports. Flat ware like plates and saucers is supported by spurs placed on iron frames. Nappies and like ware are turned with their faces together and placed between flats or biscuit plates. The temperature of the kiln is commonly raised to the fusion point of cone 03. Cones 016 and 03 are used for testing the temperature of the kiln.

METHODS OF MANUFACTURE OF VARIOUS WARES.

In the preceding pages the different steps in the manufacture of pottery products have been given, but not all varieties of wares pass through all these processes. For that reason the following pages will contain a brief discussion of the methods of manufacture of some of the principal pottery products.

Earthenware.

Earthenware is made of a low grade of pottery clay and is usually red-burning. Sometimes a higher grade of clay is used and the burned ware is white or cream colored. When white burning clays are used they must be burned at a higher temperature in order to secure the requisite strength. The clay is used as it is taken from the pit. It is tempered in a chaser or pug-mill. The ware is molded by hand on the potter's wheel or the smaller objects are pressed in a plunger machine, while the larger are molded on the jolly. The ware is burned in an up-draft kiln and is usually unglazed. The red burning ware is burned at a low temperature. Flower pots form the principal object of manufacture.

Yellow Ware.

Yellow ware is used for domestic purposes and is expected to withstand sudden changes of temperature. It is manufactured from a medium grade of pottery clay. The clay is first weathered, then blunged and sieved. After passing through the filter press it is pugged. The molding is done by throwing, jollying or pressing. After being finished the ware is fired in the biscuit kiln and dipped in the glaze, which is an artificial mixture. The ware is then fired in the glost kiln and dressed.

Rockingham Ware.

This ware is manufactured from the same kind of clay and by the same methods as yellow ware. There is a difference in the composition of the glaze. The glaze for the Rockingham ware contains Albany slip-clay and some lead and manganese compounds. The glazed ware is brown or black.

Stoneware.

Stoneware is a variety of pottery which is burned to the point of vitrification, so that the body is no longer porous. The color of the body is of little importance, as it is usually covered with an opaque glaze. Stoneware is manufactured of medium to low grade refractory clays. The clay is often used just as it is taken from the pit, being tempered only in the pug-mill. Sometimes the clay is weathered, then put through the chaser or pug-mill. It is then wedged and molded by throwing or jollying. The ware is glazed by the use of a slip-clay which fuses at a lower temperature than the body of the ware. The slip-clay most used in this country is obtained from Albany, N. Y. It produces a brown opaque glaze, but the color may be varied by the use of pigments. The objects are dipped in the liquid clay. Only one firing is required, since the body of the ware reaches the required hardness at the temperature at which the glaze fuses.

Stoneware is glazed also by the use of salt. The salt is thrown into the fire boxes of the kiln and volatilized. The vapors from the fire boxes pass through the kiln and unite with the clay on the surface of the ware, thus forming a glaze. Opaque white and transparent glazes are also used on stoneware. For decorative effects two kinds of glaze may be used on the same object. Up-draft and down-draft kilns are used in the manufacture of stoneware. The temperature of firing varies from cone 6 to 9.

Faience.

The term faience has received a number of applications. Bourry uses the word "to designate all permeable wares covered with a glaze." The term was originally applied to a variety of majolica made in Faenza, Italy, about the beginning of the Fourteenth Century. The term is commonly applied to a pottery with a permeable body which is decorated in many colors and glazed. Some clay workers restrict the term to those permeable wares of colored body which is covered with a clear glaze. It is an earthenware which may be made by the use of moderately low grade pottery clays. The clays are weathered, blunged, filter-pressed and pugged. The molding is done by throwing, pressing, jollying and casting. The colors are added to the body with brush. The object is then dipped in the glaze and fired. One object may be fired a great many times before the proper color effect is secured.

White Ware.

White ware is manufactured of a mixture of ball clays, kaolin, quartz and feldspar. These materials are reduced to the powdered form. They are then put into the blunger and water added, each portion being weighed in order to keep the right proportion in the mixture. After being agitated in the blunger for from an hour to an hour and a half the mixture is put through a sieve. After passing through the sieve the mixture runs through a trough into a vat. In the trough it comes in contact with magnets which remove particles of iron. In the vat the mixture is agitated until pumped into the filter-press. The leaves of clay from the filter-press are mellowed and pugged. From the pug-mill the clay is taken to the molding room. After being wedged the clay is molded by throwing, jollying or jiggering, pressing or casting. The ware is then finished and fired in the biscuit kiln. It is then brushed, receives the under glaze decoration, is glazed and fired in the glost kiln. From the glost kiln it is dressed, receives the over glaze decoration and is fired in the decorating kiln. Domestic white ware goes under the names: white granite-ware, stone china, ironstone and common china. Paris granite, commonly known as P. G. ware, is a semi-porcelain. It does not transmit the light as readily as porcelain.

Sanitary Ware.

The ingredients and the preparation of the body for sanitary ware is much the same as that for white ware. Some articles of sanitary ware have a vitrified or semi-vitrified body and a transparent glaze. Others have a soft body covered with a vitrified lining, which is in turn glazed. The articles manufactured vary in size from soap boxes to bath tubs. Large objects are molded in sections and the sections are worked together while the clay is still plastic. The bowls of lavatories are jiggered. Closet bowls are pressed by hand into plaster molds in sections.

Electrical Ware.

The mixture of ball clays, kaolins, feldspar and quartz used in the manufacture of electrical ware is similar to that employed in the manufacture of white ware. The body is burned to the point of vitrification, which occurs at about cone 12. The preparation of the body is similar to that described under white ware. The electrical insulating tubes are molded in a stiff-mud machine. The tubes are cut into sections and these sections are placed into presses where the knob ends are fashioned. Small objects like cleats and buttons are made from a semi-dry powder, in a screw press.

Porcelain.

Porcelain or china is a ware manufactured of a mixture of clays and minerals. The body of the ware is non-absorbent, vitreous, fine of grain, and translucent to transparent in thin ware. The porcelains are divided in two groups, namely, those of soft body and those of hard body and vitreous fracture. In the former clacined bones or lime phosphate is used as one of the ingredients and imparts a yellowish tinge to the body, which is visible by transmitted light. In the latter the flux used is feldspar and the color of the body, by transmitted light, is bluish-white. The other ingredients of the body mixture are kaolins, ball clays and quartz. China is burned at a higher temperature than white ware. The biscuit burn is usually low, about cone 2, while the glost burn ranges from nine to eleven cones higher. The methods of manufacture of porcelain is similar to that of white ware.

Belleek is a very thin variety of porcelain. The glaze is either dull cream or transparent. The ware receives its name from Belleek, Ireland, where it was originally manufactured. Parian ware is a white unglazed porcelain with a dense body. It is used for ornaments and busts. Delft is a variety of porcelain, ornamented in blue colors.

CHAPTER VIII.

THE CLAYS OF THE TUSCALOOSA FORMATION.

Nomenclature.—The term "Eutaw" was given by Dr. E. W. Hilgard to a group of clays and sands which forms the basal member of the Cretaceous series in Mississippi. Hilgard regarded the group as equivalent in part at least to that group which Toumey had recognized in Alabama as Lower Cretaceous in age. In 1894 Dr. E. A. Smith proposed the name "Tuscaloosa" for the Lower Cretaceous of Alabama and the gulf States. Later Ladd considering the formation in Alabama and Georgia as equivalent to the Lower Cretaceous of the Atlantic coastal plain, applied the name "Potomac" to the formation.

It was in this sense that the term was applied by the writer in a former report on some of the clays of Mississippi. The term "Tuscaloosa" is being used to apply to the formation by the present survey.

Stratigraphy.—The Tuscaloosa formation consists of beds of sand, clay, lignite and gravel. These beds overlie the eroded surface of the Sub-Carboniferous formation. The basal member of the formation consists of coarse chert gravel. From the nature of the material it is probable that these gravels were derived largely from the chert beds of the underlying Sub-Carboniferous formation. The thickness of the gravel beds vary from twenty-five to one hundred feet. The sands which overlie the gravels are bluish-green in color and strongly micaceous. In weathered zones they are yellow or rusty red in color. In many outcrops the sands are cross-bedded. They are usually non-fossiliferous, but in some places they contain fragments of lignitized wood and lenticular masses of lignite. Toward the lower horizon of the sands there occur lens-like bodies of clay and ochres. There are also beds of finely divided silica which contain a small amount of clay. Some of the beds of clay are pure white and contain a high per cent of alumina; other beds, though high in alumina, have been stained by iron so as to form ochres.

Outcrop.—The Tuscaloosa formation occupies a relatively narrow belt of outcrop in the northeastern part of the State. It occupies portions of six counties, namely, Lowndes, Monroe, Itawamba, Prentiss, Alcorn and Tishomingo.

The Tuscaloosa formation occupies but a small area in the northeastern part of Lowndes County. In Monroe County the width of the outcrop increases toward the north until at the northern line of the county it includes the eastern one-third of the surface. In Itawamba County the central and eastern portion of the county is occupied by the Tuscaloosa. The formation also extends through the central and western portions of Tishomingo County, the eastern part of Prentiss and the southeastern corner of Alcorn counties. Outliers of the Tuscaloosa formation occur on the surface of the Devo-Carboniferous area at frequent intervals. The outcrop of the Tuscaloosa is concealed over a considerable portion of the area by sand and gravels of the Lafayette and the loams of the Columbia.

Quality of the Tuscaloosa clays.—The Tuscaloosa clays are the most refractory clays that exist in the State. Some of them are infusible at exceedingly high temperatures. In degree of whiteness after burning they are superior as a rule to the other clays of the State. In chemical composition they exhibit an exceedingly high aluminum content in most outcrops, though some outcrops contain a high percentage of silica. However, because of its white color and extreme fineness of grain the presence of the silica is concealed from ordinary observation. Nevertheless the chemical analysis reveals its presence in large quantities in some instances. The following table exhibits the chemical constituents of a number of samples of the Tuscaloosa clays:

TABLE 7.

ANALYSES OF TUSCALOOSA CLAYS.

	No. 1	*No.* 2	*No.* 3	*No.* 4	*No.* 5	*No.* 6	*No.* 7
Moisture (H_2O)	.58	.58	.48	.59	1.18	.48	1.11
Volatile matter (CO_2)	5.20	4.78	4.82	8.00	6.39	15.01	13.88
Silicon dioxide (SiO_2)	70.81	79.23	80.03	66.85	71.03	44.23	42.92
Iron oxide (Fe_2O_3)	11.20	.67	1.68	3.77	.56	.81	.61
Aluminum oxide (Al_2O_3)	11.20	13.91	12.00	20.54	20.29	38.82	41.30
Calcium oxide (CaO)	.60	.59	.26	.21	.20	.19	.37
Magnesium oxide (MgO)	.50	.21	.00	.18	.13	.13	.13
Sulphur trioxide (SO_3)	trace	trace	trace	trace	.25	.45	.18
Total	100.00	99.97	99.27	100.14	99.98	100.12	100.57

These clays are all from Tishomingo County. Clay No. 1 is from the public road near the fish pond at Iuka; No. 2 is from near the public road about two miles south of Old Eastport; No. 3 is from the R. W.

Peden farm, and No. 4 is from the Jas. Turner farm. No. 5 is from the Casselberry farm near Gravel Switch; No. 6 is from the Starkey farm near Mingo Bridge, and No. 7 is from the John Walker farm, north of Iuka.

The Tuscaloosa formation contains two general classes of clays: Ball clays and white ware clays. The latter are represented by those clays which are low in iron content in the above table. The ball clays are represented by such clays as those from the Davidson, Summerford and Kennedy localities in Itawamba County.

TISHOMINGO COUNTY.

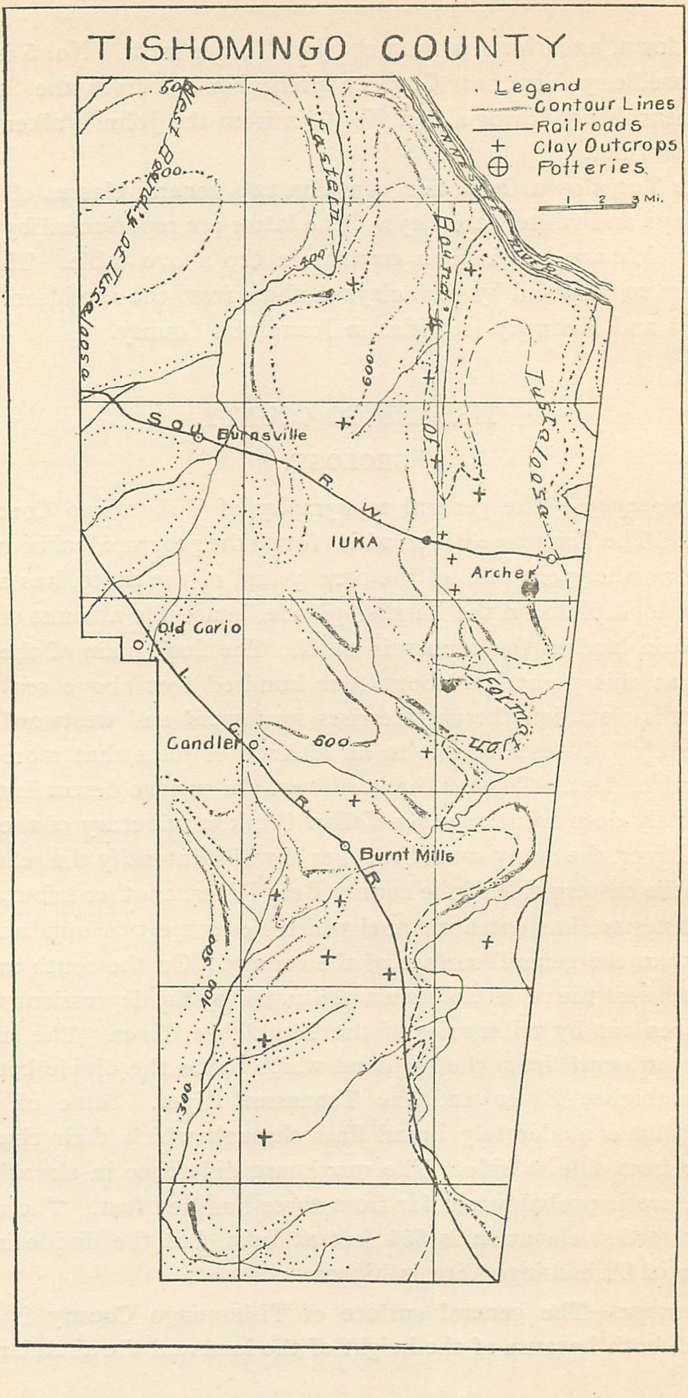
GEOLOGY.

Topography.—The general topography of Tishomingo County is rugged. The Tennessee River, which forms the geographical boundary for the northeastern part of the county and of the State, has a very narrow flood plain on the Mississippi side, hence the amount of level flood-plain land in the county is small. The flood-plain of the Tennessee at this point lies about four hundred feet above sea level. From this elevation the surface rises southward and westward by a moderately bold escarpment to an altitude of somewhat more than six hundred feet. Toward the northwest the surface descends to the moderately deep trench cut by Yellow Creek, a tributary of the Tennessee River, the many small branches of which intensify the relief.

On the eastern side of the county Bear River, another tributary of the Tennessee, has cut a channel which lies some two hundred feet lower than the general surface of the county. On the south and on the southwest the relief has been accentuated by the depressions which have been cut by tributaries of the Tombigbee River. The surface slopes southward from the highland which forms the divide between the Tombigbee River and the Tennessee River. Some of these streams have moderately broad flats through which their channels wander from side to side. The maximum difference in elevation of the surface is probably not far from three hundred feet. The maximum recorded elevation is 554 feet at Iuka, but the divide in the vicinity of Tishomingo City is higher.

Drainage.—The general surface of Tishomingo County is well-drained, both because of the height of the land and the abundance of

Plate XVI.



TISHOMINGO COUNTY
Legend
Contour Lines
Railroads
Clay Outcrops
Potteries
1 2 3 Mi.
Tennessee River
West Branch of Tuscaloosa
Eastern
Bound'y of
Tuscaloosa
SOU. R. W.
Burnsville
IUKA
Archer
Old Cario
Farmacon
Candler
600
I. C. R. R.
Burnt Mills
500
400
300

the streams. The eastern part of the county is drained by Bear River and its tributaries, Big Cripple Deer, Little Cripple Deer and others. Bear River has cut a moderately deep, narrow channel into the plateau-like eastern portion of the county. The flood-plain of the stream is narrow, and consequently the area of swamp lands along its course is small. The drainage slopes of the stream are of high gradient and the water passes off rapidly.

The northern part of the county is drained chiefly by the Tennessee River and Yellow Creek, which is a tributary of the Tennessee River. The surface of the higher lands descends rapidly to the flood-plains of these streams, and poorly drained areas are few on these slopes. The southwestern part of the county is drained by several branches and small tributaries of the Tombigbee River. This southwestern slope is not as steep as the northern slope from the divide, but the drainage is good.

Transportation facilities.—The Tennessee River and Bear River afford possible means of cheap transportation for the clays and clay products of Tishomingo County. Many good clay deposits occur within short distances of these streams. The Southern Railroad crosses the north part of the county from east to west. Some of the deposits containing the highest grade clays in the county lie easily accessible to this railroad. The Illinois Central Railroad crosses the county diagonally from northwest to southeast and intersects a large area of the Tuscaloosa clay belt. Many exposures of these clays are to be found along the line of this road, especially in the vicinities of Burnt Mills and of Tishomingo City.

Stratigraphy.—The bed rock formations of Tishomingo County consist of strata belonging to the Devonian period, the Sub-Carboniferous period and the Tuscaloosa and Eutaw divisions of the Cretaceous period. The Devonian rocks are shales and limestones. They outcrop along the banks of the Tennessee River and some of its tributaries in Tishomingo County. The rocks of the exposures consist for the most part of dark blue fossiliferous limestones with an overburden of cherts and shales. The underlying rocks, as disclosed by well records, consist of limestones, sandstones and shales. A drilled well near Old Eastport pierced more than seven hundred feet of these rocks.

The Sub-Carboniferous rocks overlie the Devonian rocks in Tishomingo County, and there appears no evidence of unconformity between the strata. The Sub-Carboniferous rocks consist of limestones, cherts, shales and sandstones of marine deposition. Outcrops of Sub-Carboniferous rocks are abundant along the bluffs of Bear River, Yellow Creek and the Tennessee River. In some places the layers of chert have disintegrated into a finely divided white silicious powder. On the old Candler farm near Bear River there is a bed of the silica which has a thickness of 15 feet. A blue limestone underlies these beds of chert. The limestone outcrops along the bluffs of Bear River and in the bed of a small creek at Old Eastport. The chemical composition of the silica and of the underlying limestone is given on page 154 of Bulletin 2 of the Mississippi Geological Survey.

A bed of pale blue limestone lies at a higher horizon than the above mentioned chert. Outcrops of it occur along the bluffs of Bear River and in the vicinity of Cypress pond. The limestone is hard and compact and occurs in beds of suitable thickness for structural purposes. Overlying the limestones are beds of dark slate colored shales. These shales, in weathering, break up into thin flakes, which by the oxidation of the iron compounds contained in them change to a red or yellow color. These shales are in many places very fossiliferous and frequently contain thin beds of limestone which may be composed almost wholly of two or three fossil species. The chemical composition of the shale and the underlying limestone is given on page 155 of Bulletin 2 of the Mississippi Geological Survey. A thick bed of sandstone lies at a higher horizon than the shale. Exposures of this sandstone are found on the banks of Bear River about three miles southeast of Tishomingo City. The sandstone forms the cap-rock for an escarpment which rises on the west side of the stream to a height of 170 feet above the water level. The top layer is broken up into large blocks. Some of these lie scattered down the slope toward the river. One of these blocks measures 43 x 10 x 12 feet. The sandstone is fine of grain, compact and suitable for building and other structural purposes.

The interval of time which intervened between the Sub-Carboniferous and the Lower Cretaceous is not represented in Mississippi. If any of the intervening formations were deposited in Mississippi they were either removed by erosion or so deeply buried by later formations as not to appear at the surface. We have reason to believe that the

Upper Carboniferous rocks were deposited since they overlie the Sub-Carboniferous rocks only a short distance away in Alabama.

The Tuscaloosa formation consists of gravels, sands and clays with intercalated beds of lignite. The formation rests unconformably upon the eroded surface of the Sub-Carboniferous. It occupies the sub-surface of the greater part of Tishomingo County. The gravels of the formation are weathered cherts from the Sub-Carboniferous chert beds. The clays generally contain a high per cent of alumina. They are either white in color or weather white on exposure. In some outcrops they are stained with iron to such a degree as to render them suitable mineral pigments. Other outcrops of the Tuscaloosa clays contain a high per cent of white silica. The extreme fineness of grain and whiteness of the silica conceal its presence in the white clay.

The Eutaw formation of the Cretaceous period occupies the sub-surface of the northwestern portion of Tishomingo County. The Eutaw formation consists of greenish colored sands containing, in some localities, indurated layers of irregularly bedded sandstones, and in other places thin laminæ of clay. The sands are micaceous and contain some calcareous matter which increases in amount toward the upper horizon, where it passes by a gradual transition into the overlying Selma chalk The upper beds are usually abundantly fossiliferous. The lower beds are less fossiliferous and contain irregular masses of indurated materials, concretions of iron sulphide, lignite and lignitic clays.

The mantle rocks of Tishomingo County include the Lafayette, the Columbia and the alluvium of the Tennessee bottoms. The Lafayette formation consists of beds of sand, gravel and clay. The gravels are mainly weathered and eroded cherts from the Tuscaloosa and the Sub-Carboniferous formations. The Lafayette contains red and orange colored sand and sandy clays. The sands in many localities contain iron stones of varying shape and size. The Lafayette mantles the older formations, resting upon them unconformably and appearing most prominently upon the ridges of high land between the streams because it is here least affected by erosion.

The Columbia formation consists of a yellow loam which is ordinarily only a few feet thick and in many places is very sandy. The line of contact of the Columbia with the underlying Lafayette is generally marked by a thin layer of water-worn pebbles of small size and lenticular shape.

CLAYS AND CLAY INDUSTRY.

Penniwinkle Hill.—The following geological section is exposed about four miles south of Iuka at Penniwinkle Hill:

Section at Penniwinkle Hill.

3. Blue micaceous clay changing to yellow	5 feet.
2. Gray laminated micaceous clay containing thin iron stone layers	20 feet.
1. Bluish-white, jointed clay	15 feet.

The upper layer (3) of the section is a transition in color at least to the Lafayette red sands which lie above. The bluish clay at the base of the section belongs to the Tuscaloosa formation. It is the only member of the section that is of economic importance. The physical properties of the clay are as follows: It slakes rapidly and all of it may be washed through a screen of 150 mesh. It has a tensile strength of 36 pounds. The amount of water required for plasticity is 25 per cent. It has an air shrinkage of 6 per cent. At cone 19 its fire shrinkage was less than 1 per cent. During firing the clay undergoes the following changes:

TABLE 8.

CHANGES OF PENNIWINKLE HILL CLAY DURING FIRING.

Clay cone	....	....	....	....
Pyrometric cone	cl	2	19	20
Color	white	white	white	white
Hardness	soft	soft	med. hard	med. hard
Shrinkage	....	....	—1	—1
Absorption	17	18	14	14

The chemical composition of the clay is given in the following table:

TABLE 9.

ANALYSIS OF PENNIWINKLE CLAY.

Moisture (H_2O)	1.09
Volatile matter (CO_2, etc.)	7.34
Silicon dioxide (SiO_2)	68.65
Ferric oxide (Fe_2O_3)	2.77
Aluminum oxide (Al_2O_3)	18.99
Calcium oxide (CaO)	.20
Magnesium oxide (MgO)	.20
Sulphur trioxide (SO_3)	Trace
Total	99.24

RATIONAL ANALYSIS.

Clay substance	48.12
Free silica	39.52
Fluxing impurities	3.17

PLATE XVII.

A. AN OUTCROP OF TUSCALOOSA CLAY AT PENNIWINKLE HILL, TISHOMINGO COUNTY. MASSIVE CLAY AT BOTTOM, LAMINATED CLAY ABOVE.

B. AN OUTCROP OF TUSCALOOSA GRAVEL AT GRAVEL SIDING, TISHOMINGO CO.

When this clay was mixed with 50 per cent of Moscow road clay (see Kemper County) the mixture vitrified and burned to a bluish-gray color at cone 20. It received the natural slip glaze without cracking and formed a good, strong body.

Paden farm.—An outcrop of white silicious clay occurs on the Wesley Paden farm four miles southwest of Tishomingo City. The clay bed is exposed in the bank of a small stream eastward from the Paden house. The full thickness of the bed is not exposed, but the outcrop has a thickness of about twelve feet. The overburden of the clay is a bed of gravel which in places has been cemented by iron oxide into a pudding stone. The clay is impervious and the ground water flows out along its upper surface and forms fine springs of clear water.

The white clay contains a high per cent of fine sand and slakes very rapidly. It has an average tensile strength of 40 pounds per square inch and requires 33 per cent of water to render it plastic. Its specific gravity varies from 2.51 to 2.60 At cone 20 the clay burned to a white hard body, which was without absorption. The burned body was like a brittle stone. It also contained some small cracks.

The chemical composition of the clay is given in the following table:

TABLE 10.

ANALYSIS OF PADEN CLAY.

Moisture (H_2O)	.48
Volatile matter (CO_2, etc.)	4.82
Silicon dioxide (SiO_2)	80.03
Ferric oxide (Fe_2O_3)	1.68
Aluminum oxide (Al_2O_3)	12.00
Calcium oxide (CaO)	.26
Magnesium oxide (MgO)	.....
Sulphur trioxide (SO_3)	Trace
Total	99.27

RATIONAL ANALYSIS.

Clay substance	30.41
Free silica	61.62
Fluxing impurities	2.18

Thorne farm.—On the R. F. Thorne farm about six miles north of Iuka there is an outcrop of red clay which has an overburden of Lafayette sand. The red clay belongs to the Tuscaloosa formation.

The thickness of the layer is 15 feet. It is a light red clay containing concretion-like masses of deeper red, or in some instances pure white.

The chemical composition of the clay is given in the following table:

TABLE 11.

ANALYSIS OF THORNE CLAY.

Moisture (H_2O)	.97
Volatile matter (CO_2, etc.)	11.96
Silicon dioxide (SiO_2)	38.11
Ferric oxide (Fe_2O_3)	11.73
Aluminum oxide (Fe_2O_3)	36.42
Calcium oxide (CaO)	.60
Magnesium oxide (MgO)	.14
Sulphur trioxide (SO_3)	Trace
Total	99.83

RATIONAL ANALYSIS.

Clay substance	92.20
Free silica	.....
Fluxing impurities	12.47

The average tensile strength of the air dried brickettes is 26 pounds per square inch. It becomes plastic when mixed with 30 per cent of water. It slakes readily and has an air shrinkage of 4 per cent. At the temperature of cone 20 the clay is vitrified, red in color and has no absorption. The percentage of iron in the clay is sufficient to produce a very good ochre or mineral paint. It has been used for that purpose locally.

Fish pond near Iuka.—A light red clay occurs at the base of an outcrop of laminated clays interstratified with thin layers of sand near the fish pond northeast of Iuka. The laminated clays of the outcrop are of various colors, bluish-gray predominating. The interstratified sands contain many muscovite crystals and streaks of ochre. A platy form of cleavage is characteristic of some of the layers of clay. The upper layers of clay contain more sand. The chemical composition of the clay is given below:

TABLE 12.

ANALYSIS OF FISH POND CLAY.

Moisture (H_2O)	.58
Volatile matter (CO_2, etc.)	5.20
Silicon dioxide (SiO_2)	70.81
Ferric Oxide (Fe_2O_3)	11.20
Aluminum oxide (Al_2O_3)	11.20
Calcium oxide (CaO)	.60
Magnesium oxide (MgO)	.50
Sulphur trioxide (SO_3)	Trace
Total	100.09

RATIONAL ANALYSIS.

Clay substance	28.00
Free silica	53.86
Fluxing impurities	12.30

The thicker clay bed, the analysis of which is given above, is composed of a clay which has a specific gravity varying from 2.48 to 2.64. The clay slakes rapidly and has an average tensile strength of 30 pounds per square inch. It requires 25 per cent of water to render it plastic. The air shrinkage of the clay is 5 per cent.

Starkey farm.—White clays occur in two outcrops on the J. F. Starkey farm near Mingo. The outcrops are in gullies on the banks of a small stream. The exposed layer has a thickness of 10 or 15 feet.

The weathered portion is stained with iron oxide, the freshly exposed clay is bluish-white in color, but becomes chalk white upon exposure. The overburden of the clay is red sand. The chemical composition of a sample of the clay is given below:

TABLE 13.

ANALYSIS OF STARKEY CLAY.

Moisture (H_2O)	.48
Volatile matter (CO_2, etc.)	15.01
Silicon dioxide (SiO_2)	44.23
Iron oxide (Fe_2O_3)	.81
Aluminum oxide (Al_2O_3)	38.82
Calcium oxide (CaO)	.19
Magnesium oxide (MgO)	.13
Sulphur trioxide (SO_3)	.45
Total	100.12

RATIONAL ANALYSIS.

Clay substance	98.21
Free silica	.....
Fluxing impurities	1.58

Brown farm.—An outcrop of Tuscaloosa clay was found on the Tilman Brown farm about four miles north of Iuka. The clay bed is in the bank of a small creek which crosses the farm in an east and west direction. At the base of the exposure there is about 6 feet of white clay. Above the white clay there is a layer of mottled clay having a thickness of 2 feet. Overlying the mottled clay there is a bed of red clay which has a thickness of 10 feet. The full thickness of the white clay was not exposed.

A sample of the white clay slaked very rapidly, and all of it was washed through a screen of 150 mesh except about 2 per cent of it. The clay was white and hard, but unfused at the temperature of cone 20. It exhibited some cracks, was brittle and had an absorption of 11 per cent. A sample of the mottled clay burned to a cream color, was hard, and had an absorption of 16 per cent at the temperature of cone 20.

The chemical composition of a sample of the red clay is given in the following table:

TABLE 14.

ANALYSIS OF TILMAN BROWN CLAY.

Moisture (H_2O)	1.19
Volatile matter (CO_2, etc.)	8.00
Silicon dioxide (SiO_2)	39.35
Aluminum oxide (Al_2O_3)	38.73
Iron oxide (Fe_2O_3)	9.39
Calcium oxide (CaO)	.34
Magnesium oxide (MgO)	.23
Sulphur trioxide (SO_3)	.51
Sodium oxide (Na_2O)	.35
Potassium oxide (K_2O)	.12
Total	98.21

RATIONAL ANALYSIS.

Clay substance	87.99
Free silica	.....
Fluxing impurities	10.94

The chemical composition of the white clay is probably the same except for the iron oxide which must be present in very small quantities. When mixed with the more plastic ball clays from the Wilcox the white clay diminishes the shrinkage of the mixture.

Brown mill.—At the old Brown mill on the J. J. Aker farm is a bed of clay which has a thickness of about 20 feet. The outcrop is in the bank directly west of the old mill. In the bed of the creek just below the bridge, which is a few rods north of the old mill, there is a layer of mottled clay which is at a lower horizon than the above mentioned outcrop. The lower layer of clay at the mill is a mottled yellow and white clay which has above it a layer of white clay. The white clay is overlain by a layer of yellow clay which is in turn capped by a layer of red clay. The yellow clay is in places considerably indurated, so that its rate of slaking is slow. The white clay slakes very rapidly, but about 2 per cent of it was retained on a screen of 150 mesh. The clay burned hard at cone 20, was unfused, light red in color and absorbed 10 per cent of water.

The chemical composition of the clay is given in the following table:

TABLE 15.

ANALYSIS OF BROWN MILL CLAY.

Moisture (H_2O)	.68
Volatile matter (CO_2, etc.)	4.09
Silicon dioxide (SiO_2)	81.15
Aluminum oxide (Al_2O_3)	12.64
Iron oxide (Fe_2O_3)	.51
Magnesium oxide (MgO)	.06
Calcium oxide (CaO)	.38
Sulphur trioxide (SO_3)	.58
Sodium oxide (Na_2O)	.15
Potassium oxide (K_2O)	.37
Total	100.61

RATIONAL ANALYSIS.

Clay substance	31.98
Free silica	61.81
Fluxing impurities	2.05

Walker farm.—On the John Walker farm, about four miles north of Iuka, there is an outcrop of highly aluminous clay. The bed outcrops near the crest of a small ridge on the north side of a stream which crosses the farm from west to east. The full thickness of the bed does not appear in the outcrop. A little to the east of the outcrop and at a slightly lower level there is a bed of red ochreous clay which contains enough iron oxide to make a fairly good pigment. The bed of white clay is jointed and may be taken out in irregular blocks having a diameter of eight or ten inches.

The chemical composition of a sample of the white clay is given in the following table:

TABLE 16.

ANALYSIS OF WALKER CLAY.

Moisture (H_2O)	1.11
Volatile matter (CO_2, etc.)	13.88
Silicon dioxide (SiO_2)	42.92
Iron oxide (Fe_2O_3)	.61
Aluminum oxide (Al_2O_3)	41.30
Calcium oxide (CaO)	.37
Magnesium oxide (MgO)	.13
Sulphur trioxide (SO_3)	.18
Total	100.57

RATIONAL ANALYSIS.

Clay substance	104.48
Free silica	.....
Fluxing impurities	1.29

The percentage of alumina in the clay is 1.8 more than is required for pure kaolinite. Computed as kaolinite that amount of alumina would be sufficient to produce 104.48 per cent. The amount of silica required to combine with this amount of alumina in order to produce kaolinite is 45.65 per cent. But the total amount of silica in the clay is only 44.23 per cent, so that of the amount of silica necessary to combine with the alumina in order to form kaolinite there is lacking 1.42 per cent. This condition is due either to the presence of some mineral-like collyrite which contains a higher percentage of alumina than kaolinite or to a mixture of collyrite and kaolinite or to the presence of an aluminum oxide, such as gibbsite.

Turner farm.—A white plastic clay occurs on the James Turner farm on Section 15, T. 4 R., 11 E. This clay requires about 30 per cent of water to render it plastic. Its average specific gravity is 2.61. In air drying it shrinks 4 per cent. The total shrinkage is 10 per cent. The air-dried brickettes have an average tensile strength of 35 pounds. When placed in water it slakes rapidly to grains of medium size. The chemical composition of the clay is given in the table which follows:

TABLE 17.

ANALYSIS OF TURNER CLAY.

Moisture (H_2O)	.59
Volatile matter (CO_2, etc.)	8.00
Silicon dioxide (SiO_2)	66.85
Ferric oxide (Fe_2O_3)	3.77
Aluminum oxide (Al_2O_3)	20.54
Calcium oxide (CaO)	.21
Magnesium oxide (MgO)	.18
Sulphur trioxide (SO_3)	Trace
Total	100.14

RATIONAL ANALYSIS.

Clay substance	52.05
Free silica	35.34
Fluxing impurities	4.16

This clay remained unfused at a temperature which fused cone 20. The body of the burned clay is hard and the color white. A red clay overlying the white burned red, became hard but absorbed 14 per cent of water at cone 20.

Rowe farm.—In a gully on one side of the public road about one mile south of the old Eastport mill there is an outcrop of bluish-gray plastic clay which weathers white when freshly exposed. The outcrop is about 5 feet in thickness and is partly concealed by Lafayette sands, which attain a considerable thickness to the right of the exposure.

The chemical properties of the clay are given in the following table:

TABLE 18.

ANALYSIS OF ROWE CLAY.

Moisture (H_2O)	.55
Volatile matter (CO_2, etc.)	4.78
Silicon dioxide (SiO_2)	79.23
Ferric oxide (Fe_2O_3)	.67
Aluminum oxide (Al_2O_3)	13.91
Calcium oxide (CaO)	.59
Magnesium oxide (MgO)	.21
Sulphur trioxide (SO_3)	Trace
Total	99.97

RATIONAL ANALYSIS.

Clay substance	48.23
Free silica	41.36
Fluxing impurities	1.47

The physical properties of the clay are as follows: It has an average tensile strength of 50 pounds per square inch. Its specific gravity ranges from 2.48 to 2.64. The amount of water required to render the clay plastic is 33 per cent of its weight. In water it slakes very rapidly to grains of medium size. The free silica in the clay is in a very finely divided state, since all of it was washed through a screen of 150 mesh. The clay remains unfused at the fusion point of cone 20. When fashioned and burned in the form of a small vessel it produced a strong white body without cracks or crazes.

Casselberry farm.—A bed of white clay was found on the Casselberry farm about half a mile south of Gravel Siding. The bed of clay has a thickness of 12 feet or more. The clay is exposed at the base of a small ridge. It has also been reached from the upper surface of the ridge by means of a well, and doubtless occupies a considerable area of the sub-surface.

The physical properties of a sample of the clay are as follows: The rate of slaking is very rapid. Less than 1 per cent could not be washed through a screen of 150 mesh. The clay undergoes the following changes during firing:

TABLE 19.

CHANGES OF CASSELBERRY CLAY DURING FIRING.

Clay cone:						
Pyrometric cone........	01	3	4	8	13	20
Color................	white	white	white	white	white	white
Hardness.............	soft	soft	soft	soft	soft	soft
Shrinkage............	....	....	....	....	....	.....
Absorption...........	16	17	20	15	10	10

The chemical composition of the clay is given in the following table:

TABLE 20.

ANALYSIS OF CASSELBERRY CLAY.

Moisture (H_2O)............	1.18
Volatile matter (CO_2, etc.)............	6.39
Silicon dioxide (SiO_2)............	71.03
Iron oxide (Fe_2O_3)............	.56
Aluminum oxide (Al_2O_3)............	20.29
Calcium oxide (CaO)............	.20
Magnesium oxide (MgO)............	.13
Sulphur trioxide (SO_3)............	.25
Total............	99.98

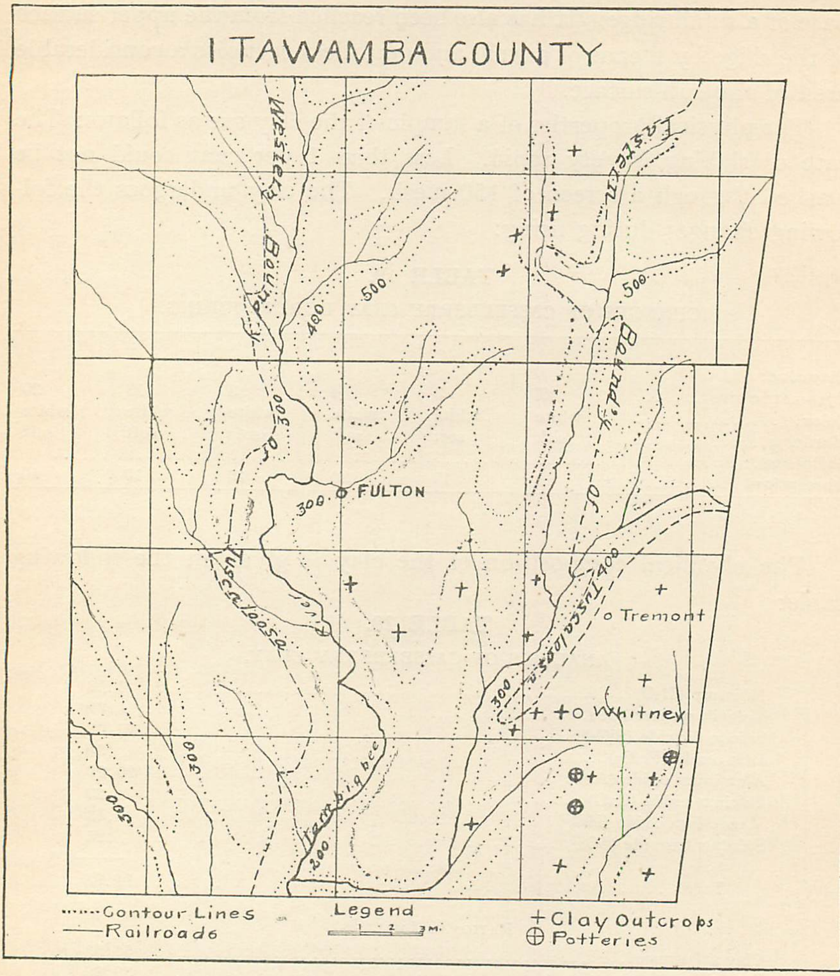
RATIONAL ANALYSIS.

Clay substance............	51.33
Free silica............	39.99
Fluxing impurities............	1.23

Clements farm.—A bed of white clay is located on the D. W. Clements farm five miles south of Dennis and two and one-half miles southwest of Belmont. The length of the outcrop is about 30 rods and the thickness is over 6 feet, though the total thickness has not been revealed.

The clay has about the same properties as the Sharkey clay, which has been described in previous pages.

PLATE XVIII.



ITAWAMBA COUNTY.

GEOLOGY.

Topography.—The northeastern portion of Itawamba County is occupied by a plateau-like area, which lies between 500 and 600 feet above sea level. On the western side of the highland the surface descends by gently rolling land to the flood-plain of the Tombigbee River. West of the Tombigbee River the land rises rather abruptly to an elevation of a few hundred feet above the flood-plain. The surface of the county has a variation in altitude of about 400 feet. The highest elevations are in the plateau-like area in the northeastern part of the county. The lowest elevations are found along the flood-plain of the Tombigbee River in the southern part of the county. The flood-plains of this river and of Bull Mountain Creek contain the lowlands of the county. Bull Mountain Creek has cut a trench through the highland in the eastern part of the county. The borders of this trench are marked by broken lands. Between the Tombigbee River and Bull Mountain Creek there is a ridge of highland which extends northward and unites with the eastern highland.

Drainage.—The drainage of Itawamba County is accomplished by the Tombigbee River and some of its branches. The Tombigbee River crosses the county from north to south a little west of the central part of the county. Its largest eastern branch is Bull Mountain Creek, which heads in Franklin County, Alabama. Bull Mountain Creek controls the drainage for the eastern part of Itawamba County. Its principal northern branch, Gum Creek, rises in the northeastern part of the county and flows south into Bull Mountain. The principal eastern branch of the latter is Dry Creek. Other branches of Bull Mountain are Hickory Creek, Cypress Creek, Hurricane Creek, John's Creek and Lickskillet Creek. The southeastern part of the county is drained by Splunge Creek, a branch of the Buttahatchie River.

The other eastern branches of the Tombigbee River are Mud Creek and Comenis Creek. Meadow Creek, Twenty Mile Creek and Manachee Creek are the principal western branches of the Tombigbee River.

Stratigraphy.—The bed rock of a small area in the northeastern part of Itawamba County belongs to the Sub-Carboniferous formation. The area lies for the most part in the triangle formed by the union of Gum Creek and Bull Mountain Creek. The central and southern portions of the county are occupied by the Tuscaloosa formation. The Eutaw formation forms the bed rock for the western part of the county. The two last named formations are of Cretaceous age. The surficial formations consist of sands, gravels and clays of Lafayette age and yellow loams of Columbia age.

The high grade clays of the county belong to the Tuscaloosa formation. On the eastern side of the county exposures of these clays are numerous. Up to the present time the use of these clays has been confined to stoneware purposes. The refractory nature of some of the clays from this formation adapt them for the manufacture of fireproof goods.

Transportation facilities.—Itawamba County is at present without railroad transportation. This condition has been a serious drawback to the development of the clay industry. Because of the lack of adequate transportation facilities the small potteries of the county have been compelled to dispose of the products of their potteries to a very local trade.

CLAY AND CLAY INDUSTRY.

Summerford pottery.—There is a white potter's clay on the W. A. Summerford farm about four miles south of Whitney. The clay is white or a yellowish white with streaks of blue. The thickness of the clay at the exposure is about 6 feet. Less than .05 per cent of this clay was caught on a screen of 150 mesh. At cone 17 in muffle the clay burned light pink color and vitrified. At cone 20 it remained unchanged. The clay takes both the artificial glaze and the slip g'aze without cracking. The amount of water required for plasticity is 20 per cent. The loss of weight in burning is 3 per cent. The air shrinkage is 8 per cent. The total shrinkage at cone 17 is 8 per cent. The rate of slaking is rapid. It was very slow in one sample (puddled). The tensile strength is 111 pounds per square inch. The following table shows the changes which take place in the clay at different temperatures. Small clay cones were used for the tests. The clay vitrifies, turns gray and shows no absorption at cone 20.

TABLE 21.

CHANGES IN SUMMERFORD CLAY IN BURNING.

Clay cone				
Pyrometric cone	01	9	19	20
Color	white	yellow	yellowish gray	gray
Hardness	soft	steel hard	steel hard	steel hard
Shrinkage	....	5	5	5
Absorption	25	....	....	....

The chemical properties of the clay are exhibited in the following table:

TABLE 22.

ANALYSIS OF SUMMERFORD CLAY.

Moisture (H_2O)	.77
Volatile matter (CO_2, etc.)	6.77
Silicon dioxide (SiO_2)	62.58
Aluminum oxide (Al_2O_3)	27.58
Ferric oxide (Fe_2O_3)	1.57
Calcium oxide (CaO)	.40
Magnesium oxide (MgO)	Trace
Sulphur trioxide (SO_3)	Trace
Total	99.67

RATIONAL ANALYSIS.

Clay substance	69.89
Free silica	20.27
Fluxing impurities	1.97

Uses.—Mr. Summerford has used this clay for a number of years in the manufacture of jugs, jars, crocks and churns. He produces about 5,000 gallons per year. The ware is thrown by the use of a "kick" wheel. It is burned in a small rectangular kiln having a capacity of 500 gallons. The clay pit is only a few rods from the pottery. The clay is mixed and placed in open log bins and allowed to weather. It is tempered in a vertical pug mill.

Davidson's pottery.—The James Davidson pottery is located at Whitney. It has not been in operation for a few years. When operated it produced stoneware and tombstones. The clay used occurs near the public road west of Whitney. It is a mottled red and pink clay which is cream-colored when reduced to powder. The clay bed has a thickness of 6 feet and has an overburden consisting of thinly bedded sands and clays containing attenuated layers of ironstone. Ten per cent of the clay was retained on the screen of 150 mesh. The amount of water required for plasticity is 25 per cent. The average tensile strength is 80 pounds per square inch. In the muffle at cone 12 the clay assumed a cream color and became hard. At cone 20 it vitrified and assumed a reddish-yellow color. The qualities of the slip and artificial glaze on the raw clay are good. The air shrinkage of the clay is 8 per cent. The fire shrinkage was 7 per cent. Total shrinkage 15 per cent.

The chemical composition of the clay follows:

TABLE 23.

ANALYSIS OF DAVIDSON CLAY.

Moisture (H_2O)	.54
Volatile matter (CO_2, etc.)	7.40
Silicon dioxide (SiO_2)	59.12
Aluminum oxide (Al_2O_3)	27.44
Ferric oxide (Fe_2O_3)	4.39
Calcium oxide (CaO)	.34
Sulphur trioxide (SO_3)	Trace
Total	99.23

RATIONAL ANALYSIS.

Clay substance	69.54
Free silica	17.02
Fluxing impurities	5.01

Uses.—For a number of years Mr. James Davidson used the above clay in the manufacture of a general line of stoneware. The clay is tempered in a small horse-power pug mill and thrown upon a "kick" wheel. Mr. Davidson used two kilns, each having a capacity of 650 gallons.

The ware was glazed with the Albany slip clay. This clay produces a brown colored glaze. It is a natural clay which fuses at a lower temperature than ordinary clay. The chemical composition of a sample of the slip clay is given below:

TABLE 24.

ANALYSIS OF ALBANY SLIP CLAY.

Silicon dioxide (SiO_2)	56.75
Aluminum oxide (Al_2O_3)	15.47
Volatile matter (CO_2, etc.)	8.87
Moisture (H_2O)	.37
Ferric oxide (Fe_2O_3)	5.73
Calcium oxide (CaO)	5.78
Magnesium oxide (MgO)	3.32
Potash and soda (K_2O, Na_2O)	3.25
Total	99.54

Mr. Davidson also used this clay in the manufacture of tombstones. The stones were about 3 or 4 feet long, 2 feet wide, and were lettered in relief.

Kennedy pottery.—About three miles south of Whitney is the clay pit and pottery of Mr. E. P. Kennedy. The pit is near the public road and the outcrop shows 4 or 5 feet of mottled clay, white color predominating. The chemical composition of a sample of the clay is given below:

TABLE 25.

ANALYSIS OF KENNEDY CLAY.

Moisture (H_2O)	2.71
Volatile matter (CO_2, etc.)	5.91
Silicon dioxide (SiO_2)	71.53
Aluminum oxide (Al_2O_3)	14.46
Ferric oxide (Fe_2O_3)	4.14
Calcium oxide (CaO)	.62
Magnesium oxide (MgO)	.55
Sulphur trioxide (SO_3)	.....
Total	99.92

RATIONAL ANALYSIS.

Clay substance	36.64
Free silica	49.35
Fluxing impurities	5.31

The specific gravity of the clay was 2.5. The maximum tensile strength was 120 pounds per square inch. It requires about 30 per cent of water for plasticity. The air shrinkage is 8 per cent.

Mr. Kennedy uses the slip glaze for his ware. The capacity of the plant is from 7,000 to 8,000 gallons per year. The pottery manufactures churns, jars and jugs. The ware is burned for 12 hours. The plant consists of one kiln, and employs two turners.

In the muffle at cone 20 the clay vitrified, turned dark gray and shows no absorption.

Reedville.—On the farm of Mr. William Reed, one-half mile east o Reedville, there is a bed of white Tuscaloosa clay. The clay has the following chemical properties:

TABLE 26.

ANALYSIS OF REED CLAY.

Moisture (H_2O)	3.03
Volatile matter (CO_2, etc.)	6.66
Silicon dioxide (SiO_2)	66.70
Aluminum oxide (Al_2O_3)	1.22
Ferric oxide (Fe_2O_3)	3.60
Calcium oxide (CaO)	.57
Magnesium oxide (MgO)	.47
Sulphur trioxide (SO_3)	.22
Total	99.47

RATIONAL ANALYSIS.

Clay substance	46.17
Free silica	38.75
Fluxing impurities	4.14

The amount of water required for plasticity is 30 per cent. The specific gravity is 2.10. The clay remained unfused at the temperature required to fuse cone 20. At that temperature it was vitrified and had no absorption.

Uses.—The Reed clay could be used in the manufacture of stoneware and also in the manufacture of fireproof wares.

Spring Creek.—At the point where the Roper Springs road crosses Spring Creek there is an outcrop containing the following members:

6. Red sand (Lafayette)	10 feet.
5. Rocks concealed for	15 feet.
4. Blue clay	4 feet.
3. Sand and thin sandstone	10 feet.
2. Sandstone containing clay	2 feet.
1. Blue clay	6 feet.

Farther back from the stream, at a higher level, gravels of Lafayette age occur; at a still higher level a reddish sandy clay has an overburden of yellowish loam, probably Columbia.

The bluish clay at the base of the section has a specific gravity of 2.47. It slakes slowly to coarse grain. The average tensile strength of the air-dried brickettes is 113 pounds; the maximum strength is 120 pounds. Water required for plasticity is 32 per cent. The air shrinkage is 7 per cent, the fire shrinkage 2 per cent. This clay was vitrified but unfused at the temperature required to fuse cone 13.

Uses.—The Spring Creek clay may be classed as a stoneware clay.

Bowan carding factory.—On the Cooper place, near the Bowan carding mill, there is an exposure of white plastic clay which has a thickness of 15 of more feet. The clay occurs in a hill which has a height of 100 or 150 feet. It is located on the west side of Bull Mountain Creek. The rocks above and below the clay bed consist of laminated beds of sand and clay. At cone 17 in the muffle the clay burned to a light pink color and vitrified without cracking. In the flame at cone 17 the clay turned slate color, vitrified and cracked. The amount of water required for plasticity is 19 per cent. Loss of weight in burning 5½ per cent. The air shrinkage is 8 per cent, the fire shrinkage 4 per cent, total shrinkage 12 per cent. The rate of slaking is very rapid. It vitrifies, turns white and shows no absorption at cone 20.

Uses.—The Cooper clay may be used in the manufacture of stoneware and low or medium grade fireproof wares.

Plunkett pottery.—Mr. John Plunkett operates a small hand pottery about one and one-half miles west of the Alabama line on the Bexar road. The pottery has been in operation about six or seven years. It produces annually about 2,000 gallons of stoneware. No samples of clay were collected from the Plunkett clay pit. The clay is said to be very similar to the Kennedy and other clays of that vicinity.

Palmer farm.—On the W. H. Palmer farm, south of Fulton about four miles, there is a layer of plastic blue clay which outcrops on the side of a small draw. The total thickness of the layer is not exposed, but it is said to be 12 feet. The clay was used many years ago in the manufacture of stoneware by W. M. Cheney.

Other localities.—A white plastic clay was found on the J. L. Bookout farm at Otis. The outcrop of the clay is in the feed lot a few rods west of the house. About five feet of the thickness of the clay bed is exposed. This clay is suitable for stoneware.

Similar clays occur on the old Davidson farm, one-half mile west of Whitney; on the Gaines Horn and the George Sanders farms one mile west; and in the public road one and one-half miles west of Whitney.

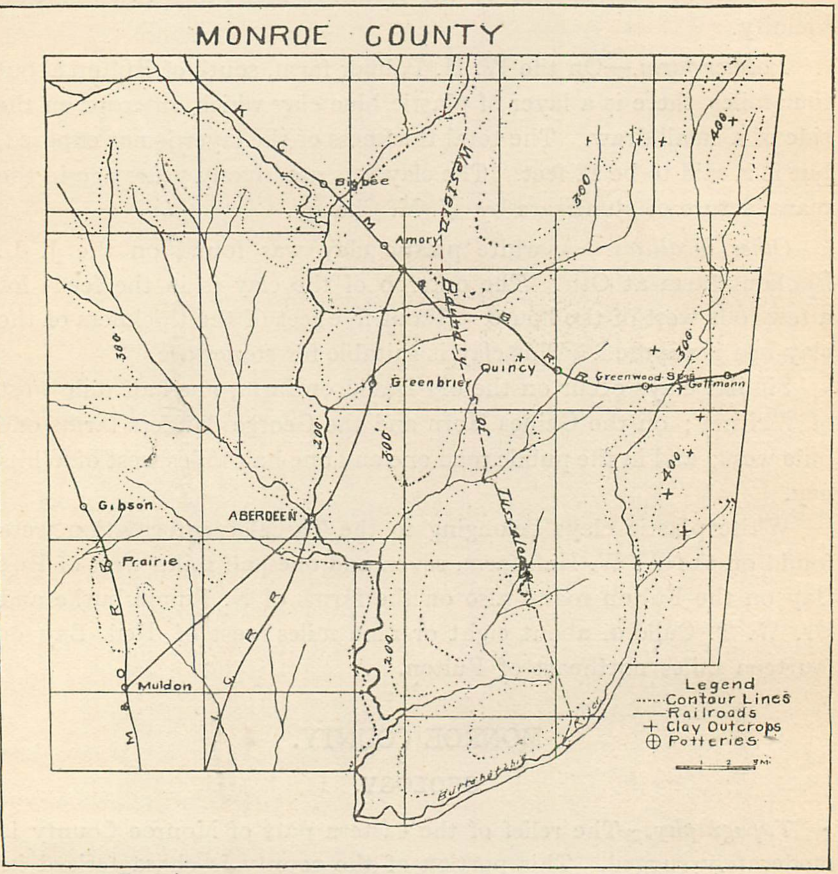
White plastic clays belonging to the Tuscaloosa formation were found on the W. W. Hall farm, seven and one-half miles west of Red Bay on the Fulton road; also on the farms of N. Funderburke and Dr. W. T. Cullom, about eight or nine miles west of Red Bay or fourteen miles northeast of Fulton.

MONROE COUNTY.

GEOLOGY.

Topography.—The relief of the eastern part of Monroe County is moderately rugged. This portion of the county is characterized in general by ridges separated by narrow valleys and in some instances by deep gulches The highest of these ridges rises for more than 200 feet above the Tombigbee valley. In this area erosion is rapid after the slopes have been deforested and the relief is then greatly accentuated. Careful methods of cultivation are essential to prevent great yearly loss of productive lands. The Buttahatchie River has cut a relatively broad trench through this portion of the county. The valley is about a mile in width and contains a very narrow first bottom and a wide second bottom. West of this eastern highland lies the valley of the Tombigbee River, which is at an elevation of about 200 feet above sea level. The Tombigbee valley contains a narrow first bottom,

PLATE XIX.



subject to annual overflow, and a much broader second bottom, at a higher elevation and subject only to occasional overflow, usually not oftener than once in ten years. West of the Tombigbee valley the surface rises abruptly to a rolling prairie, which is about 100 feet higher on the average than the valley. The flood-plain on the west side of the river is generally very narrow. The greater part of the surface of the county lies at an elevation between 200 and 300 feet above sea level. The lowest elevations are in the Tombigbee valley in the southern part of the county.

Drainage.—The Tombigbee River crosses Monroe County from a little west of a central line. Its principal eastern tributary is the Buttahatchie River, which enters the county from the east and flows south and west and forms a part of the southern boundary of the county from the point where it turns west to the point of its confluence with the Tombigbee River. Sipsey Creek is the main eastern branch of Buttahatchie River and Splunge Creek is the main northern branch. Weaver Creek, Halfway Creek, Nichols Creek and Kinsley Creek are short eastern branches of the Tombigbee River, which contribute to the drainage of the eastern part of the county. The northwest portion of the county is drained by Old Town Creek and its branches. Old Town Creek is a branch of the Tombigbee River. The eastern tributaries of the former are Cowpen Creek and Hanging Kettle Creek; the principal western branch is Tuckahioba Creek. The western part of the county is drained by Matibbee Creek. The latter has two branches, Cedar Creek on the south and Wolf Creek on the north.

Stratigraphy.—The bed rock formations of Monroe County are the Tuscaloosa, the Eutaw and the Selma, all belonging to the Cretaceous period. The Tuscaloosa formation, which consists of clays, sand and gravels containing lignites, forms an outcrop about twelve miles in width, extending through the eastern part of the county. The outcrop increases in width from north to south. The Eutaw formation occupies a narrow belt about six miles in width in the central part of the county. The Tombigbee River marks its western boundary for the greater part of its extent through the county. The Eutaw consists of beds of micaceous sands, arenaceous clays, marls and lignitic clays containing in many places nodules of iron pyrites.

The Selma, which occupies a belt extending across the western part of the county, consists of chalky marls of a bluish color in fresh exposures, but weathering white or yellow on exposed surfaces. The soils formed upon the weathered surface of the chalk belong to the black prairie type of soils. The mantle rock formations belong to the Lafayette, the Columbia and the recent alluvium of the flood-plain areas. The Lafayette has been very largely removed from the surface of the Selma Only a few isolated outcrops remain. The hills in the eastern part of the county are mantled with layers of reddish clays and sands and gravels. In some places the latter are cemented into conglomerates. The Columbia loams are usually yellow or brown in color and overlie the Lafayette.

Transportation facilities.—Monroe County is crossed by the Tombigbee River, a navigable stream, and is also well supplied with railroads. The Kansas City, Memphis & Birmingham Railroad crosses the northeastern part of the county and sends out a branch from Amory to Aberdeen. The Mobile & Ohio Railroad crosses the southwestern corner of the county, passes northward and sends off a branch from Muldon to Aberdeen. The Aberdeen Branch of the Illinois Central Railroad crosses the southern part of the county, extending as far north as Aberdeen. The Aberdeen & Tombigbee Valley Railroad, which is under construction, will extend from Okolona to Columbus, through Aberdeen.

CLAYS AND CLAY INDUSTRY.

Fox Store.—On the J. L. Coker place at Fox Store there are two layers of clay which are exposed in the public road. One outcrop is at the foot of the hill east of the store, the other is near the top of the hill west of the store. The lower layer is inclosed by layers of red sand and the upper layer has an overburden of red sand. The clays contain very little coarse material, as less than 1 per cent was retained on a screen of 150 mesh. At cone 17 the upper clay was cream colored and vitrified. At cone 20 it was unfused. The wet molded brickettes have an average tensile strength of 75 pounds per square inch. The amount of water required for plasticity is 28 per cent. The loss of weight in burning is 6 per cent. The air shrinkage is 12 per cent, and the total shrinkage is 16 per cent at cone 20.

The clay from the upper layer vitrifies at cone 13 and is not fused at cone 20. The tensile strength of the air-dried brickettes is 111 pounds per square inch. The amount of water required for plasticity is 25 per cent. The air shrinkage is 12 per cent and the total amount of shrinkage is 17 per cent. The loss of weight in burning is 5 per cent. The clay is slow in slaking and exhibits no absorption at cone 20.

Uses.—These clays may be classed as stoneware clays. Because of the presence of some pyrite the clays should be weathered for several months before being used.

Johnson farm.—On the Frank Johnson farm, one mile west of Fox Store, there is an outcrop of gray plastic clay which burns to a light yellow color and is vitrified at cone 17, but remains unfused at cone 20. The amount of water required for plasticity is 20 per cent. The loss of weight in burning is 4 per cent. The air shrinkage is 8 per cent and the total shrinkage at cone 20 is 16 per cent. In the flame the clay exhibited incipient viscosity at cone 20 and at the same temperature in the muffle it had no absorption.

Uses.—This clay may be used in the manufacture of stoneware.

Quincy.—There is an outcrop of gray clay in the public road about one mile west of Quincy. The exposed thickness of the clay is 6 or 8 feet. The clay bed has an overburden of cross-bedded micaceous sand. In the flame at cone 13 the clay was completely fused. In the muffle at cone 17 it became red, swollen and cracked. The amount of water required for plasticity is 26 per cent. The rate of slaking is rapid. The loss of weight in burning is 10 per cent. The air shrinkage is 16 per cent. The clay will not receive either a slip clay or artificial glaze.

Uses.—The Quincy clay cannot be used except in the manufacture of brick and red earthenware.

Dean farm.—An outcrop of Tuscaloosa blue clay was found on the farm of Mr. Walter Dean, about two and one-half miles north of Greenwood station. The clay overlies a bed of lignite. It has a thickness at one point, according to a well record, of about 12 feet. A sample of this clay vitrified in the muffle at cone 17 without cracking. In the flame at cone 20 it was dark blue in color, vitrified, but not fused. The clay has a tensile strength of 84 pounds per square inch. The amount of water required for plasticity is 23 per cent. The rate of slaking is rapid. The loss of weight in burning is 3½ per cent. The air shrinkage is 12 per cent. The fire shrinkage is 4 per cent. The total shrinkage is 16 per cent, at cone 17. The clay exhibits incipient viscosity at cone 20. The raw clay takes the slip glaze poorly.

Uses.—This clay is best used for light colored unglazed ware.

Nix farm.—A pinkish white clay occurs on the L. M. Nix farm, one mile east of Cochran's bridge. There is a'so an outcrop in the public road one-half mile north of this point. Another outcrop occurs one mile north of the Lowndes County line and three miles west of the Alabama line. These clays are white clays belonging to the Tuscaloosa formation. No tests have as yet been made of them, but they are doubtless very much like the Summerford and Davidson clays.

CHAPTER IX.

THE CLAYS OF THE WILCOX FORMATION.

Nomenclature.—In his report on the Agriculture and Geology of Mississippi published in 1860, Dr. E. W. Hilgard gave the name Northern Lignitic to the basal member of the Eocene division of the Tertiary. To that portion of the outcrop known topographically as the "Flatwoods" he applied the term "Flatwoods clay." Later the term "Lagrange" was applied to that portion of the Lignitic which lies above the Flatwoods clay. The term was used recently in that sense by Glenn and by the writer. (See Bulletin No. 2, Some Clays of Mississippi, 1905.) Portions of the Lignitic are included in the division Bluff Lignitic, Porters Creek and Lagrange as used by Safford in Tennessee and in the Hickman group as used by Loughridge in Kentucky.

In Alabama Smith and Johnson have defined the following horizons in this basal Eocene member: 1. Hatchetigbee. 2. Bashi. 3. Tuscahoma. 4. Nanafalia. 5. Naheola. 6. Sucarnochee, the last named being the lowermost.

In Mississippi the present survey has adopted the name Porters Creek for the lowermost part of the Liginitic, and the term Wilcox is now applied to that portion of the Lignitic lying above the Porters Creek or Flatwoods. The term Clayton has been applied to a group of rocks formerly assigned to the upper part of the Ripley and the Porters Creek and Clayton are considered parts of the Midway group.

Topography.—The Wilcox area is a highland having, for the most part, a gently rolling surface. The highland is bordered on the east by a relatively low and level area called the Flatwoods. From the lowland the surface rises with moderate abruptness to the plateau-like surface of the highland which lies at an altitude usually 200 or 300 feet higher than the bordering lowland. On the southern and south-western borders of the Wilcox area the descent from the highland is more gradual. But in the northern part of the area the outcrop is bordered on the west by the Yazoo basin, a low river plain which lies between 100 and 200 feet above sea level. The descent from the highland to this plain is by a scarp which varies from 200 to 300 feet in height.

The altitude of the southern part of the Wilcox area is about 400 feet above sea level. Northward the surface rises to an elevation of more than 600 feet and comprises the most elevated lands in the State. The highland of the Wilcox forms the main divide between the Tombigbee River and the Tennessee River on the east, the Pascagoula River on the south and the Pearl River and branches of the Mississippi on the west. The Tallahatchie River and the Yalobusha River, two branches of the Mississippi, have cut through the Wilcox area into the Midway which lies to the east of the main divide.

Outcrop.—The outcrop of the Wilcox formation extends across Mississippi in a general northwest direction from the eastern border of Lauderdale County to the north line of the State, the center of the outcrop at the north line being nearly 89° 15′ west longitude. From the Alabama line to the southern border of Webster County the outcrop maintains a fairly uniform width of about thirty miles. Beyond this point the width of the outcrop increases rapidly to more than double this figure at the north line of the State. A part of the natural outcrop of the Wilcox is concealed by the alluvial deposits of the Mississippi River in the northwestern part of the State. A considerable portion of the outcrop is concealed by the loess in the northern portion of the State and by the Lafayette and the Columbia in other parts of the area.

Stratigraphy.—The Wilcox formation is composed of beds of sand, clay and lignite. The sands are not uncommonly cross-bedded and variegated. The color of the sands varies from white through many shades of cream, pink and orange to red. In some places there are iron concretions, some of which are filled with sand particles. The rocks as a whole are non-fossiliferous. However, in the northern part of the area, especially in Marshall County, some of the Wilcox clays contain the impression of leaves of trees. The sands in all portions of the outcrop contain the petrified fragments of trees. In the southern part of the area, particularly in Lauderdale and Kemper Counties, there are ironstone concretions and irregular layers of ironstone which contain marine shells. A bed of loose sand a mile northwest of Lockhart contains Ostrea shells.

The clay industry.—The clay industry in the Wilcox area has not received that development which the quality of the clay warrants. At the present time only one steam pottery is in operation within the area occupied by its outcrop. At Holly Springs a steam pottery is in operation and also a hand pottery. At these potteries a general line of stoneware is manufactured. A few years ago a small hand pottery was operated at Cumberland, in Webster County. This pottery has recently suspended operations. Representatives of three generations of the Loyd family have manufactured stoneware in a small hand pottery near Webster, in Winston County. The pottery is located south of Webster, near the old Dr. Eiland plantation, from which the clay is obtained. A few miles southeast of the Eiland plantation Homer Stewart operates a small hand pottery. Other small potteries have existed in this neighborhood for short periods of time. A steam pottery was in operation at a point on the Mobile & Ohio Railroad, one mile north of Lockhart, in Lauderdale County. This pottery has changed hands a number of times since its inception about 1870. The plant is not now in operation. At one time clay was shipped from the Eakin farm, in eastern Lauderdale, to Meridian, where it was used in the manufacture of stoneware. The Meridian pottery is no longer in operation. The clay from the Eakin place is still being hauled to Cuba, Alabama, to be used in the manufacture of stoneware.

MARSHALL COUNTY.

GEOLOGY.

Topography.—The surface of Marshall County is a gently undulating plain, the highest point of which lies between 600 and 650 feet above sea level. Owing to the incoherent nature of some of its surficial rocks the surface has been eroded, in places, into a bad land type of topography. Deep gulches and crenulated cirques are not uncommon at the heads of small streams. The central highland is bordered on the northwest by the lowland of the Coldwater River, and on the south by the lowlands of the Tippah and the Tallahatchie Rivers. These valleys lie at the elevation of 300 feet below the highlands. The maximum difference in the altitude is about 350 feet. The highest recorded elevation in the county and in the State is 609 feet at Holly Springs. The minimum recorded elevation is 334 feet at Potts Camp, on the Tippah River. However, there are lower altitudes on the Tippah River and on the Coldwater River.

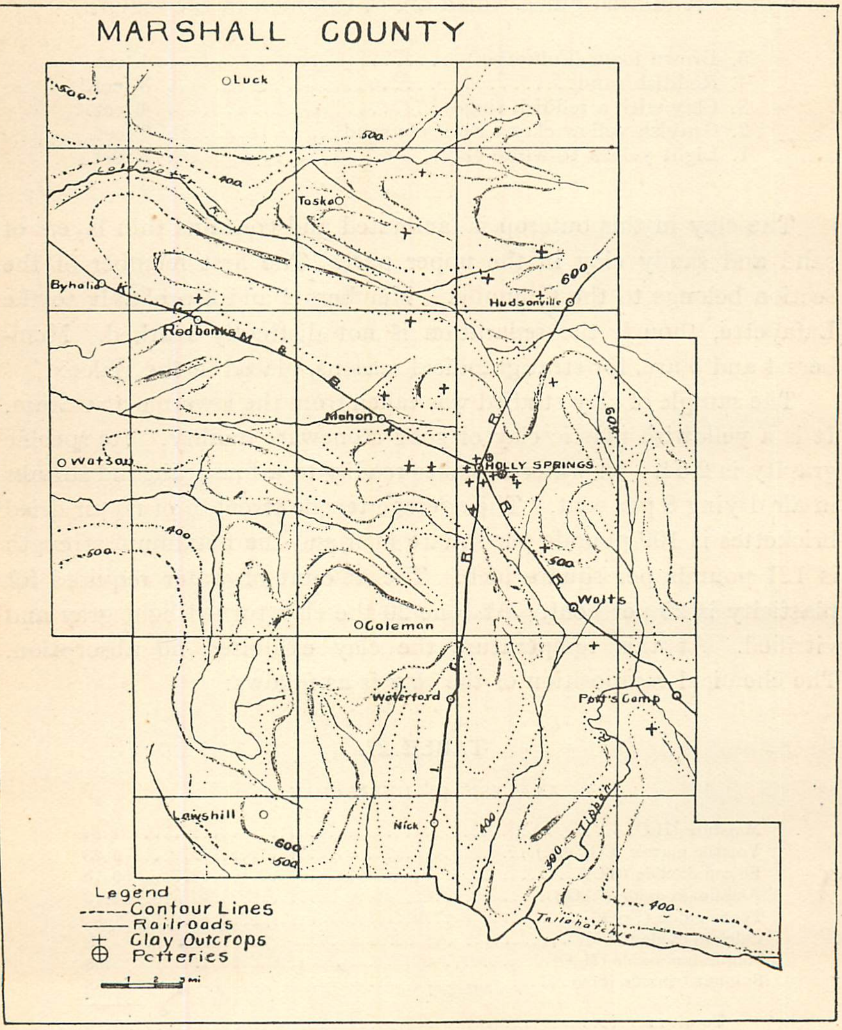
Drainage.—The main part of Marshall County is drained by the Coldwater River, which sends out many branches to enter the county from the west Pigeon Roost Creek and Bank Creek are important branches of the Coldwater in Marshall County. Blackwater Creek and Big Spring Creek are branches of the Tallahatchie River, which forms a part of the southern boundary of the county. These streams, together with Tippah River, another branch, drain the southern part of the county.

Stratigraphy.—Marshall County lies wholly within the area occupied by the Wilcox as a bed rock formation. The Wilcox is composed principally of sands and clays. The clays are usually massive jointed clays imbedded in sands. They contain the impressions of the leaves of trees in some outcrops. The sands are generally red or pink in color and in many places contain partings or lenticular masses of clay. There are also thin ironstone layers and concretions in some exposures. The concretions often take the form of irregular tubes.

The Lafayette, which overlies the Wilcox, reflects many of the characters of the bed rock. In most places the Lafayette has appropriated so much of the materials (apparently) of the sub-terrane as to be almost indistinguishable from it. The presence of beds of lignite and the impressions of leaves are the criteria which have led to a separation of the two in many localities. The conclusion has been reached that much of the formation formerly assigned to the Lafayette in Marshall County belongs to the Wilcox. The surface of the Lafayette in Marshall County is covered pretty generally with a brown loam which has been assigned to the Columbia.

Transportation facilities.—Two roads cross the county and intersect at Holly Springs. The Illinois Central Railroad crosses the county from north to south. The Kansas City, Memphis & Birmingham Railroad traverses the county in a northeast-southwest direction. Both of these roads cross territory occupied by outcrops of Wilcox clays.

PLATE XX.



MARSHALL COUNTY
Luck
Taska
Byhalia
Redbanks
Hudsonville
Mahon
Watson
HOLLY SPRINGS
Walts
Coleman
Waterford
Pott's Camp
Lawshill
Nick
Tallahatchie
Legend
Contour Lines
Railroads
Clay Outcrops
Potteries

CLAYS AND CLAY INDUSTRY.

Butler Hern Farm.—On the Butler Hern farm, two miles west of Holly Springs, the following geological section is exposed in a small cusp of a crenulated gulch which are so common in the region:

5. Brown loam (Columbia)	4 feet.
4. Reddish sand	3 feet.
3. Clay with a reddish tinge	4 feet.
2. Grayish yellow clay with some sand	5 feet.
1. Light yellow to white clay	5 feet.

The clay in this outcrop is laminated and contains thin layers of sand and sandy clay in the upper part. The first member of the section belongs to the Columbia. Members 2 and 3 probably to the Lafayette, though the separation is not distinctly marked. Members 4 and 5 are, for stratigraphical reasons, placed in the Wilcox.

The sample of clay studied was taken from the lowermost stratum. It is a yellowish plastic clay of good stoneware quality. Its specific gravity is 2.54. In water it slakes readily to a fine grain and shrinks in air drying 8 per cent. The average tensile strength of its air dried brickettes is 109 pounds per square inch and the maximum strength is 121 pounds per square inch. The amount of water required for plasticity is 25 per cent. At cone 20 the clay turned light gray and vitrified. At this temperature the clay exhibited no absorption. The chemical composition of the clay is as follows:

TABLE 27.

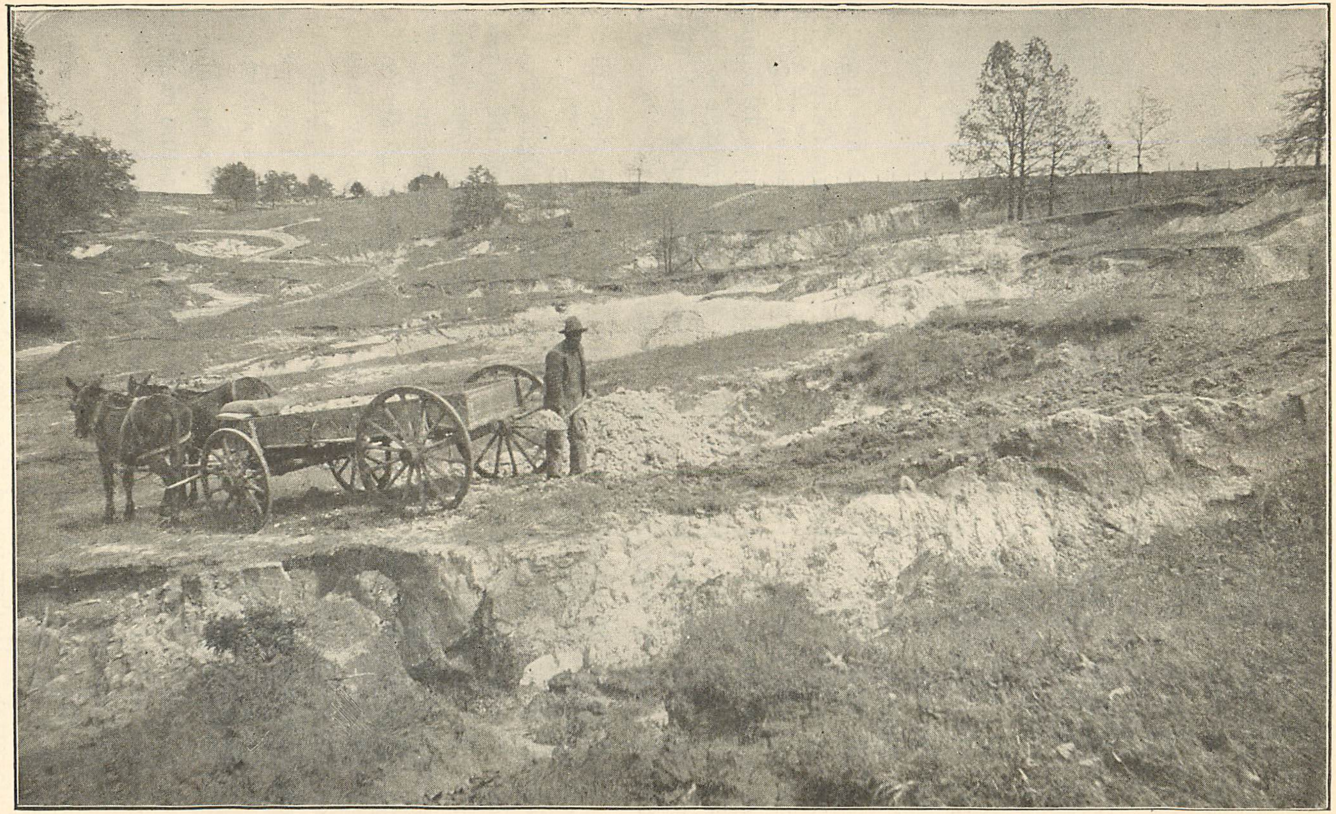
ANALYSIS OF HERN CLAY.

Moisture (H_2O)	1.84
Volatile matter (CO_2, etc.)	8.23
Silicon dioxide (SiO_2)	60.78
Aluminum oxide (Al_2O_3)	24.12
Ferric oxide (Fe_2O_3)	3.52
Calcium oxide (CaO)	.73
Magnesium oxide (MgO)	.38
Sulphur trioxide (SO_3)	.38
Total	99.98

RATIONAL ANALYSIS.

Clay substance	61.12
Free silica	23.28
Fluxing impurities	4.62

Plate XXI.



CLAY PIT OF THE HOLLY SPRINGS STONEWARE AND FIRE BRICK COMPANY.

This is a good quality of stoneware clay, the ware when burned having a good, strong body, drying and burning readily. It could without doubt be used in the manufacture of a general line of stoneware.

Old Hern Farm.—On the old Hern farm, one and one-half miles west of Holly Springs, there is an old clay pit formerly worked by the Holly Springs Stoneware Company. At this point four or five feet of white clay with yellow and pink streaks is exposed. Above the clay there is a bed of red sand (Lafayette). Higher up on the ridge the Columbia appears. In a deep cut at the side of the road near this point 30 or 40 feet of the red Lafayette sands are revealed. The clay at the base of the sand is Wilcox.

This clay possesses the following properties: It has a specific gravity of 2.50. In water it slakes readily to medium flakes. The average tensile strength is 68 pounds and the maximum is 75 pounds per square inch. In air drying it shrinks 5 per cent. It requires 25 per cent of water to render it plastic. The fire shrinkage is about two per cent. When burned it becomes white, dense and hard. It has the proper degree of plasticity for easy molding.

Ray farm.—In a small draw on the W. J. Ray farm, one-half mile west of Holly Springs, there is an outcrop of white clay. The thickness of the clay, as it is exposed, is 6 or 8 feet. Judging from its position it belongs to the Wilcox. An examination of the physical properties of the clay reveals a specific gravity of 2.53. The average tensile strength of the brickettes is 65 pounds per square inch. The amount of water required to make the clay plastic is 25 per cent of the amount of clay used. When dried in the air the clay shrinks 6 per cent. The fire shrinkage is 4 per cent The clay burns to a dense white body. At the temperature necessary to fuse cone 20 the clay turns to a gray or white color, vitrifies and has no absorption.

Holly Springs Stoneware Company Pit.—In the new pit opened by the Holly Springs Stoneware Company there is a stratum of white or cream colored clay which has a thickness of about 8 feet. This pit is one and one-fourth miles east of Holly Springs.

The clay is a fossil-leaf bearing and laminated. It doubtless belongs to the Wilcox. Overlying the clay is a bed of reddish sand (Lafayette). Higher up on the slope above the bed of the small run in which the clay outcrops, the brown loam of the Columbia appears. The Holly Springs Stoneware Company used this clay in the manufacture of a general line of stoneware. The articles manufactured include jugs, jars, crocks, churns, pitchers, bowls, and flower pots.

The clay is mixed in a chaser or wet pan. The plant is run by steam power and the clay vessels dried by steam heat. The vessels are burned in two circular, down-draught kilns of the bee-hive type. Coal is used as fuel. The clay vitrifies between cones 5 and 6. Both a white and a brown glaze is used. The white glaze is obtained by a mixture containing feldspar and whiting. The brown glaze is produced by using the Albany slip clay. A very attractive vessel is made by using the white glaze for the body of the ware and the brown for the top or rim. The capacity of this plant is 500,000 gallons per year. A chemical analysis of a sample of clay from this pit gave the following results:

TABLE 28.

ANALYSIS OF HOLLY SPRINGS CLAY.

Moisture (H_2O)	.94
Volatile matter (CO_2, etc.)	6.64
Silicon dioxide (SiO_2)	67.70
Aluminum oxide (Al_2O_3)	16.69
Ferric oxide (Fe_2O_3)	3.04
Calcium oxide (CaO)	1.06
Magnesium oxide (MgO)	.58
Sulphur trioxide (SO_3)	.19
Total	99.84

RATIONAL ANALYSIS.

Clay substance	49.90
Free silica	37.49
Fluxing impurities	4.68

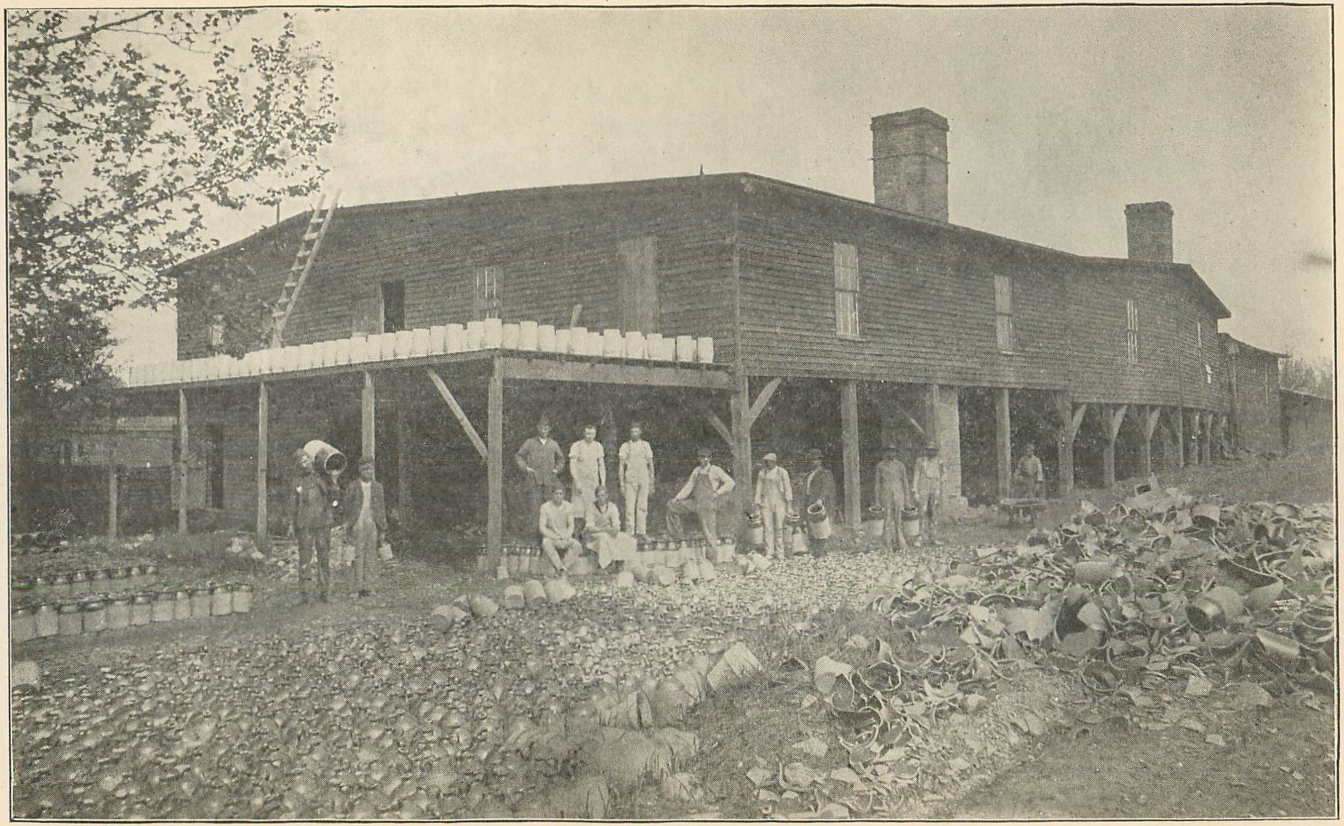
This bed of clay varies in the amount of sandy matter both vertically and horizontally. Averaging the above analysis with that of a sample taken a few rods away the following results are obtained:

TABLE 29.

ANALYSIS OF HOLLY SPRINGS CLAY.

Moisture (H_2O)	1.23
Volatile matter (CO_2, etc.)	7.35
Silicon dioxide (SiO_2)	64.69
Aluminum oxide (Al_2O_3)	22.30
Ferric oxide (Fe_2O_3)	2.54
Calcium oxide (CaO)	.70
Magnesium oxide (MgO)	.70
Sulphur trioxide (SO_3)	.20
Total	99.71

PLATE XXII.



POTTERY OF THE HOLLY SPRINGS STONEWARE AND FIRE BRICK COMPANY

In order to compare this clay with other stoneware clays now in use we will take the rational analysis obtained from the above analysis and compare it with the average rational analysis of ten clays given by Hopkins:

TABLE 30.

COMPARISON OF HOLLY SPRINGS AND PENNSYLVANIA CLAYS.

	Holly Springs Clay	*Pennsylvania Clay*
Clay substance	56.51	56.65
Free silica	30.48	37.45
Fluxing impurities	3.94	4.44
Moisture	1.23	1.57
Total silica	64.69	65.00

This comparison shows that chemically the Holly Springs clay is a good stoneware clay as it varies only slightly, and not at all in a detrimental way from the average analysis of ten clays.

The color of this clay in the powdered form varies from white to cream. It has a specific gravity of 2.53. In water it slakes with moderate rapidity to a fine grain. The average tensile strength of its air dried brickettes is 58 pounds, the maximum is 62 pounds per square inch. It requires about 30 per cent of water to make it plastic. The amount of air shrinkage is 7 per cent. The following table shows the changes the clay undergoes during firing:

TABLE 31.

CHANGES IN HOLLY SPRINGS CLAY DURING FIRING.

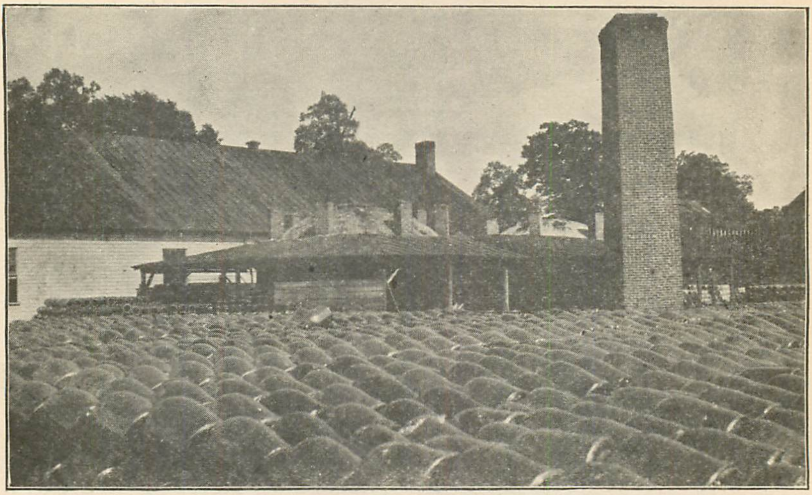
Clay cone:					
Pyrometric cone	01	2	3	7	19
Color	white	pink	pink	light yellow	light blue
Hardness	soft	soft	med. hard	hard	vitrified
Fire shrinkage	....	....	2	4	5
Absorption	20	23	23	16	....

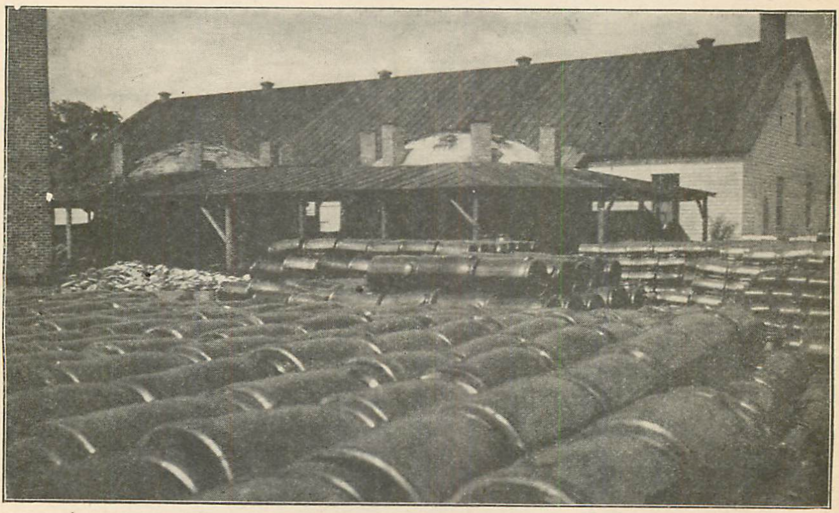
Another sample collected from a nearby outcrop has a specific gravity of 2.58; an air shrinkage of 7 per cent; an average tensile strength of 59 pounds per square inch; slakes slowly to fine flakes and requires 33 per cent of water to render plastic.

Allison Clay Pit.—The Allison Stoneware Company of Holly Springs have a clay pit a few rods north of the above outcrop. The clay used by this company is found under the following stratigraphical conditions:

4. Brown loam (Columbia) .... 2 feet.
3. Orange to red sand (Lafayette) .... 4 feet.
2. Laminated cream colored clay .... 12 feet.
1. Variegated sands .... 5 feet.

PLATE XXIII.





TWO VIEWS OF THE ALLISON POTTERY AT HOLLY SPRINGS AND SOME OF THE STONEWARE.

About one hundred yards north of this outcrop No. 2 of the section has a thickness of ten feet, while No. 1 attains a thickness of four feet. At a higher level and farther back from the creek the thickness of both of these beds increases greatly. The sands of No. 4 are cross-bedded and vary much in color, the prevailing colors are red, yellow, purple, and white. But no deep orange like that of No. 2. In the upper part are thin layers of ironstone separating thin layers of clay. The upper part of stratum No. 3 varies in color from white to yellow and is somewhat sandy. In a gulch one hundred yards north of this outcrop are some fine springs of clear sparkling water. These are formed at the line of contact between Nos. 2 and 3. The following is the chemical composition of the Allison clay:

TABLE 32.

ANALYSIS OF ALLISON CLAY.

Moisture (H_2O)	1.51
Volatile matter (CO_2, etc.)	8.07
Silicon dioxide (SiO_2)	61.69
Aluminum oxide (Al_2O_3)	24.91
Ferric oxide (Fe_2O_3)	2.04
Calcium oxide (CaO)	.34
Magnesium oxide (MgO)	.83
Sulphur Trioxide (SO_3)	.20
Total	99.59

RATIONAL ANALYSIS.

Clay substance	63.13
Free silica	23.47
Fluxing impurities	3.21

The physical properties of the clay are: Specific gravity, 2.57 to 2.58; average tensile strength of the brickettes, 113 pounds; maximum strength, 128 pounds per square inch; air shrinkage, 8 per cent. The amount of water required for plasticity is 32 per cent. In water the clay slakes readily to medium grains.

Another sample of clay from a different part of the pit gave a specific gravity of 2.38; is medium grained; has an air shrinkage of 7 per cent; is white to light yellow in color and requires 30 per cent of water to render it plastic.

The Allison pottery manufactures a general line of stoneware. They have two circular kilns and a brick oven drier. The clay is pugged in a vertical steel pug-mill. The ware is thrown, two wheels being maintained. The Albany slip glaze is used. The plant has only recently been moved and enlarged to a two-kiln plant.

Cemetery, Holly Springs.—At the southern boundary of the cemetery in Holly Springs a white or yellowish white clay underlies a deposit of reddish sand. There are several thin layers of clay separated by thin beds of sand. The geological position of the clay is not clear, but is probably Lafayette. As much as forty feet of Lafayette is exposed in a gulch at the northeastern part of the cemetery. The greater part of the outcrop is red sand or sandy clay, but toward the bottom of the outcrop are some thin layers of white clay. Doubtless they mark the beginning of the transition to the Wilcox. This forty foot stratum was encountered in the Holly Springs well.

The clay of the first named locality is very plastic and when placed in water slakes slowly to medium sized flakes. The air dried brickettes have an average tensile strength of 46 pounds and a maximum strength of 49 pounds per square inch. The specific gravity ranges from 2.20 to 2.36. It requires about one-fifth of its weight of water to render it plastic. In air drying it shrinks 6 per cent. It vitrifies at cone 20, forming a strong, dense body which is gray in color.

Public road south of Holly Springs.—In the public road about one-half of a mile south of Holly Springs there is an outcrop of cream colored clay. This clay occurs under much the same conditions as the above. It is near the line of contact of Lafayette and Wilcox. The clay has a specific gravity of 2.47. It slakes rapidly to medium grain. Its average tensile strength is 51 pounds per square inch. The amount of water required for mixing the clay is 25 per cent. It shrinks in air drying 4 per cent. It burns to a strong white body and is a good potter's clay.

One mile south of Holly Springs.—An outcrop of clay occurs on the public road one mile south of Holly Springs. The following section is exposed:

6. Brown loam (Columbia)	6 feet.
5. White clay	6 feet.
4. Sands, dark red to purple	4 feet.
3. Sandstone, red to purple, ferruginous	8 inches.
2. Loose sand and small gravel	1 foot.
1. Ferruginous sandstone	6 inches.

In another outcrop on the east side of the road No. 2 is covered with ten feet of reddish sand (Lafayette) Members of this section from 2 to 6, inclusive, belong to the Wilcox. The layers of sandstone are very irregular in thickness and are not continuous for great distances. The wine-colored to purple sands of No. 2 contain many irregular ironstone concretions. Owing to the bad land type of topography the clay outcrops are numerous in this region. Deep gulches with crenulate margins have been carved not alone in the Columbia and the Lafayette formations, but also in the sub-formational Wilcox. The white clay of No. 5 is plastic and has a specific gravity of 2.50 (average). The average tensile strength is 40 pounds per square inch. It requires about 32 per cent of water to render the clay plastic. Its air shrinkage is 6 per cent. It vitrifies at cone 20, forming a dense white body, and is without absorption.

Colored School Building, Holly Springs.—This is a white clay similar to the last occurring near the colored school building in Holly Springs. The average specific gravity is 2.40. The tensile strength of the air dried brickettes is 45 pounds per square inch. The amount of water required for plasticity is 25 per cent of the weight of the clay. The air shrinkage measured on the brickettes is 8 per cent.

Frisco Station, Holly Springs.—Near the Frisco Station in Holly Springs there is an outcrop of white fire clay of the plastic variety. Four or five feet of the clay is exposed. It is succeeded above by a yellowish loam passing to brown on top and having a thickness of five feet. The clay contains a high per cent of silica and a low per cent of fluxing impurities. It can be molded without difficulty and dries without cracking or checking. A chemical analysis of the clay gave the following results:

TABLE 33.

ANALYSIS OF FRISCO STATION CLAY.

Moisture (H_2O)	.87
Volatile matter (CO_2, etc.)	1.93
Silicon dioxide (SiO_2)	88.52
Aluminum oxide (Al_2O_3)	5.26
Ferric oxide (Fe_2O_3)	1.64
Calcium oxide (CaO)	.73
Magnesium oxide (MgO)	.13
Sulphur trioxide (SO_3)	.43
Total	99.51

RATIONAL ANALYSIS.

Clay substance	13.33
Free silica	80 45
Fluxing impurities	2.50

The specific gravity ranges from 2.56 to 2.75. Its average tensile strength is 95 pounds per square inch. Upon drying in the air it shrinks 2 per cent. The amount of water required to render the clay plastic is 15 per cent. When burnt the clay has a cream or flesh tint and a firm, compact body. This clay remains unfused at the temperature required to fuse cone No. 20. It is hard and gray and without absorption.

Illinois Central Station.—This clay was collected from an outcrop east of the Illinois Central Station in Holly Springs. It is from the same geological horizon as the one above.

It is a white highly refractory clay, containing large grains of pure clear quartz. Many of the quartz grains are as large as grains of wheat. It has an average specific gravity of 2.63. The average tensile strength of its air dried brickettes is 102 pounds per square inch. It requires about 14 per cent of water to render it plastic. It may be molded readily into bricks which do not crack on drying. It burns to a slightly pink color, which disappears before vitrification, leaving the burnt clay white or cream colored. The chemical analysis of a sample of clay taken from this horizon gave the following results:

TABLE 34.

ANALYSIS OF ILLINOIS CENTRAL STATION CLAY.

Moisture (H_2O)	1.23
Volatile matter (CO_2, etc.)	2.41
Silicon dioxide (SiO_2)	66.66
Aluminum oxide (Al_2O_3)	22.29
Ferric oxide (Fe_2O_3)	1.57
Calcium oxide (CaO)	.62
Magnesium oxide (MgO)	.28
Sulphur trioxide (SO_3)	.11
Total	95.17

RATIONAL ANALYSIS.

Clay substance	56.49
Free silica	32.46
Fluxing impurities	4.83

This clay remained unfused at the point of fusion of cone No. 20.

Brick Yard, Holly Springs.—This clay was collected from near the brick yard at Holly Springs. It is a light cream colored clay. The specific gravity of one sample is 2.30. In water it slakes readily to fine flakes. The air shrinkage is 8 per cent. At cone 20 it was unfused, but vitrified and had no absorption. The chemical composition of the clay is as follows:

TABLE 35.

ANALYSIS OF BRICK YARD CLAY.

Moisture (H_2O)	.96
Volatile matter (CO_2, etc.)	6.70
Silicon dioxide (SiO_2)	67.02
Aluminum oxide (Al_2O_3)	20.89
Ferric oxide (Fe_2O_3)	2.93
Calcium oxide (CaO)	.67
Magnesium oxide (MgO)	.55
Sulphur trioxide (SO_3)	.49
Total	100.21

RATIONAL ANALYSIS.

Clay substance	52.95
Free silica	34.96
Fluxing impurities	4.15

It may be classed as a good stoneware clay.

Dunlap Farm.—A yellowish white plastic clay was collected from the farm of J. Dunlap, four miles southeast of Holly Springs. The outcrop is near the Frisco Railroad. The chemical properties of the clay are:

TABLE 36.

ANALYSIS OF DUNLAP CLAY.

Moisture (H_2O)	.66
Volatile matter (CO_2, etc.)	7.25
Silicon dioxide (SiO_2)	62.41
Aluminum oxide (Al_2O_3)	24.02
Ferric oxide (Fe_2O_3)	2.80
Calcium oxide (CaO)	.57
Magnesium oxide (MgO)	.50
Sulphur trioxide (SO_3)	.56
Total	98.77

RATIONAL ANALYSIS.

Clay substance	60.87
Free silica	25.56
Fluxing impurities	3.87

The average specific gravity of the clay is 2.48. The air shrinkage is 4 per cent. May be classed as an excellent stoneware clay.

Ballard Farm.—A white clay was found on the Ballard farm at Holly Springs. It has a specific gravity of 2.37. It slakes readily in water to fine grain. On drying in the open air it shrinks 8 per cent. At cone 20 it was vitrified but unfused. It was gray in color and showed no absorption. The following is the chemical composition of a sample of the clay:

TABLE 37.

ANALYSIS OF BALLARD CLAY.

Moisture (H_2O)	1.74
Volatile matter (CO_2, etc.)	7.39
Silicon dioxide (SiO_2)	63.95
Aluminum oxide (Al_2O_3)	21.42
Ferric oxide (Fe_2O_3)	3.88
Calcium oxide (CaO)	.39
Magnesium oxide (MgO)	.73
Sulphur trioxide (SO_3)	.29
Total	99.79

RATIONAL ANALYSIS.

Clay substance	54.28
Free silica	31.09
Fluxing impurities	5.00

This is a potter's clay of good quality. It may be molded readily and dries and burns without checking.

Fant Farm.—North of Mahon, on the E. T. Fant farm, there is an outcrop of pinkish to white clay. This is a plastic clay exhibiting many muscovite crystals, which are visible to the unaided eye. The amount of water required to render the clay plastic is about 32 per cent. The air shrinkage is five per cent. The specific gravity of one sample was 2.25. At the temperature required to fuse cone 20 the clay is unfused, is gray in color and without absorption. A sample of yellow clay from the same locality is plastic; has a specific gravity of 2.24; an air shrinkage of 6 per cent and a tensile strength of 45 pounds per square inch.

A sample of cream colored clay from the same locality has a specific gravity of 2.40. It is plastic and shrinks in air drying 4 per cent. A sample of the pinkish clay has the following chemical composition:

TABLE 38.

ANALYSIS OF FANT CLAY.

Moisture (H_2O)	.83
Volatile matter (CO_2, etc.)	6.12
Silicon dioxide (SiO_2)	70.86
Aluminum oxide (Al_2O_3)	15.68
Ferric oxide (Fe_2O_3)	4.50
Calcium oxide (CaO)	.45
Magnesium oxide (MgO)	.79
Sulphur trioxide (SO_3)	.29
Total	99.52

PLATE XXIV.

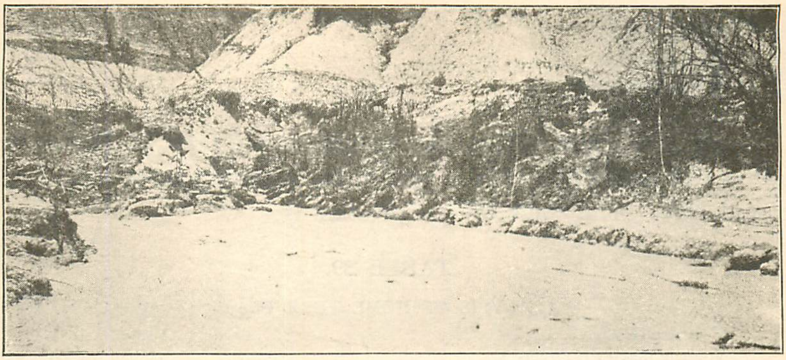


Figure 1. LAFAYETTE AND BROWN LOAM OVERLYING WILCOX, TWO MILES SOUTHWEST OF HOLLY SPRINGS.

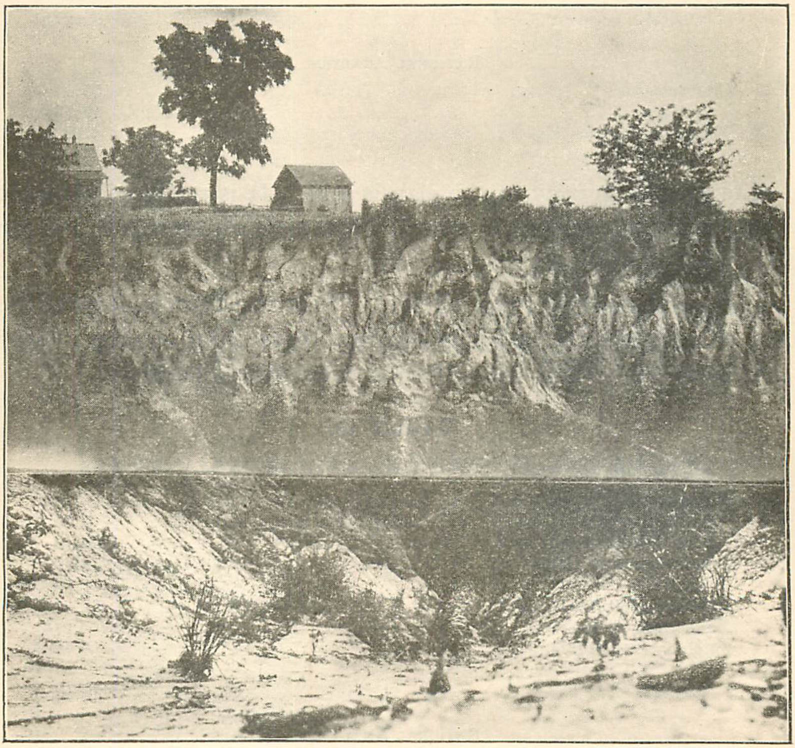


Figure 2. WHITE WILCOX CLAY OVERLYING WHITE SAND, SOUTH OF HOLLY SPRINGS.

RATIONAL ANALYSIS.

Clay substance	39.74
Free silica	46.80
Fluxing impurities	5.74

Home Terr Farm.—This clay occurs on the farm of Home Terr, west of Hudsonville. It is a yellow, or in some places, light cream colored clay. The chemical composition is:

TABLE 39.

ANALYSIS OF HOME TERR CLAY.

Moisture (H_2O)	1.92
Volatile matter (CO_2, etc.)	7.66
Silicon dioxide (SiO_2)	63.56
Aluminum oxide (Al_2O_3)	21.92
Ferric oxide (Fe_2O_3)	2.83
Calcium oxide (CaO)	.48
Magnesium oxide (MgO)	.62
Sulphur trioxide (SO_3)	.28
Total	99.27

RATIONAL ANALYSIS.

Clay substance	55.55
Free silica	29.93
Fluxing impurities	.93

The specific gravity of the clay is 2.26. It is rendered plastic by mixing with 30 per cent of water. The air shrinkage is 8 per cent. It is a good quality of stoneware clay.

Two miles south of Holly Springs.—Near the Illinois Central Railroad, two miles south of Holly Springs, there is an outcrop of white plastic clay which has the following chemical properties:

TABLE 40.

ANALYSIS OF CLAY TWO MILES SOUTH OF HOLLY SPRINGS.

Moisture (H_2O)	.74
Volatile matter (CO_2, etc.)	5.36
Silicon dioxide (SiO_2)	84.40
Aluminum oxide (Al_2O_3)	6.79
Ferric oxide (Fe_2O_3)	1.30
Calcium oxide (CaO)	.85
Magnesium oxide (MgO)	.27
Sulphur trioxide (SO_3)	.17
Total	99.88

RATIONAL ANALYSIS.

Clay substance	17.21
Free silica	73.98
Fluxing impurities	2.43

The specific gravity of the clay is 2.41. The air shrinkage is 4 per cent. This clay remained unchanged at cone 20, but it was vitrified. It had a gray color and no absorption.

Poor Farm.—A cream colored clay is found on the Marshall County poor farm. It is plastic; slakes readily in water and has a specific gravity of 2.17. The air shrinkage is 6 per cent. At cone 20 it was vitrified but unfused. It had a gray color and no absorption. The chemical composition of a sample of this clay is:

TABLE 41.

ANALYSIS OF POOR FARM CLAY.

Moisture (H_2O)	1.78
Volatile matter (CO_2, etc.)	8.11
Silicon dioxide (SiO_2)	61.31
Aluminum oxide (Al_2O_3)	24.44
Ferric oxide (Fe_2O_3)	2.77
Calcium oxide (CaO)	.57
Magnesium oxide (MgO)	.29
Sulphur trioxide (SO_3)	.23
Total	99.50

RATIONAL ANALYSIS.

Clay substance	61.94
Free silica	23.81
Fluxing impurities	3.63

This is a potter's clay of good quality.

Mahon Station.—This clay is from the railroad cut south of the Mahon station. It is a salmon colored clay, having a specific gravity of 2.51. It is gritty to the taste and contains microscopic muscovite crystals. At the temperature of cone 20 it was hard and cream colored. The absorption was .7 per cent. The chemical properties of the clay are:

TABLE 42.

ANALYSIS OF CLAY FROM MAHON STATION.

Moisture (H_2O)	.44
Volatile matter (CO_2, etc.)	4.75
Silicon dioxide (SiO_2)	77.64
Aluminum oxide (Al_2O_3)	12.33
Ferric oxide (Fe_2O_3)	3.10
Calcium oxide (CaO)	.51
Magnesium oxide (MgO)	.12
Sulphur trioxide (SO_3)	.54
Total	99.43

RATIONAL ANAALYSIS.

Clay substance	31.25
Free silica	58.72
Fluxing impurities	3.73

Rand and Norfleet.—A clay bed occurs on a farm owned by Rand and Norfleet, northwest of Holly Springs. It is a white plastic clay having the following chemical properties:

TABLE 43.

ANALYSIS OF RAND AND NORFLEET CLAY.

Moisture (H_2O)	1.23
Volatile matter (CO_2, etc.)	7.02
Silicon dioxide (SiO_2)	65.88
Aluminum oxide (Al_2O_3)	21.19
Ferric oxide (Fe_2O_3)	2.89
Calcium oxide (CaO)	.72
Magnesium oxide (MgO)	.15
Sulphur trioxide (SO_3)	.30
Total	99.38

RATIONAL ANALYSIS.

Clay substance	53.70
Free silica	33.47
Fluxing impurities	3.76

The specific gravity of the clay is 2.31. The air dried brickettes shrink 8 per cent. At a temperature required to fuse cone 20 the clay was unfused and vitrified. It had no absorption. The color of the burned clay is dark gray.

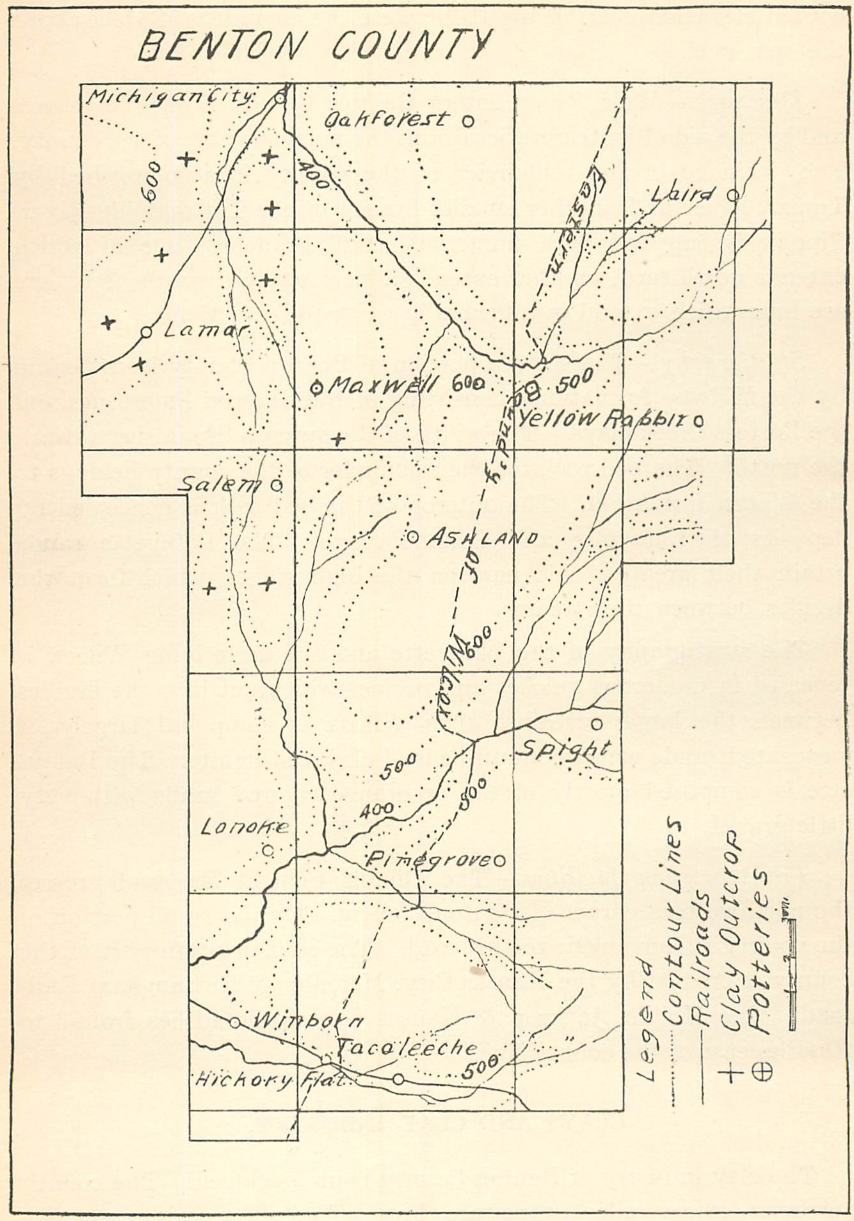
Jones Farm.—A white fire clay from the Jones place, just east of the corporation limits, Holly Springs. The clay contains a large number of visible quartz grains. It is a plastic clay and has a specific gravity of 2.67. The air dried brickettes shrink 6 per cent. The clay remained unfused at the fusion point of cone No. 19, and will probably stand a much higher temperature.

BENTON COUNTY.

GEOLOGY.

Topography.—The central part of Benton County is occupied by a table land, the surface of which is gently undulating and lies about 600 feet above sea level. This high land area lies between the valleys of Tippah and Wolf Rivers. Wolf Valley, in the northern part of the county, lies 200 feet below the level of the high land. Tippah Valley, which is located in the southern part of the county, lies from

Plate XXV.



BENTON COUNTY
Michigan City
Oakforest
Laird
Lamar
Maxwell
Yellow Rabbit
Salem
Ashland
Spight
Lonoke
Pinegrove
Winborn
Tacaleeche
Hickory Flat
600
400
500
Legend
Contour Lines
Railroads
Clay Outcrop
Potteries

250 to 300 feet below the level of the plateau. The maximum recorded elevation is at Spring Hill, where the altitude is 583 feet above the sea level.

Drainage.—Wolf River enters Benton County from Tennessee, and by the aid of its tributaries drains the northern part of the county. The drainage of the remainder of the county is accomplished by Tippah River and another smaller branch of the Tallahatchie River. Tippah is supplied with numerous small branches, one of which extends northward, another extends almost straight south and there are four which extend in a generally eastward direction.

Stratigraphy.—The eastern portion of Benton County is underlain by the Midway formations, consisting of the Clayton limestones and the Porters Creek clays. The width of the outcrop diminishes toward the north. The bed rock for the remainder of the county belongs to the Wilcox formation. The outcrop of the bed rock is concealed by deposits of Lafayette and Columbia age The Lafayette sands attain their greatest thickness on the high ridges, which form the divides between the streams.

The stratigraphy of the Lafayette and the underlying Wilcox is revealed in numerous gulches and ravines which cut into the divides between the larger streams. The Wilcox is composed largely of variegated sands which contain beds of clay and lignite. The Lafayette is composed mostly of red or orange colored sands with very little gravel.

Transportation facilities.—The Illinois Central Railroad crosses the northwestern corner of Benton County. Only a small portion of the county is convenient to this road. The southwestern part of the county is crossed by the Kansas City, Memphis & Birmingham Railroad. The Mobile, Jackson & Kansas City Railroad lies from 6 to 10 miles east of the county line.

CLAYS AND CLAY INDUSTRY.

The clay industry of Benton County is undeveloped. The county possesses some excellent stoneware clays. The following is an average of the analyses of three of its stoneware clays:

TABLE 44.

ANALYSIS OF BENTON STONEWARE CLAYS.

Moisture (H_2O)	.88
Volatile matter (CO_2, etc.)	8.09
Silicon dioxide (SiO_2)	60.07
Aluminum oxide (Al_2O_3)	25.01
Ferric oxide (Fe_2O_3)	3.35
Calcium oxide (CaO)	.54
Magnesium oxide (MgO)	.34
Sulphur trioxide (SO_3)	.25
Total	98.53

RATIONAL ANALYSIS.

Clay substance	63.42
Free silica	21.67
Fluxing impurities	4.22

Comparing the rational analysis with that of the ten foreign stoneware clays given on page 145, we obtain the following results:

	Benton Co.	*Foreign.*
Clay substance	63.43	56.65
Free silica	21.67	37.45
Fluxing impurities	4.22	4.44
Moisture	.88	1.57
Total silica	60.07	65.00

This comparison shows a higher clay base and less fluxing impurities for the Benton County clays.

Mac in Farm.—On the J. Maclin farm, southwest of Spring Hill, in Benton County, is a deposit of white plastic clay. The clay contains muscovite crystals of microscopic size. It is distinctly gritty to the taste. In water it slakes readily to a fine grain The specific gravity is 2.55. In air drying it shrinks 4 per cent At the temperature of cone 20 it vitrifies and turns to a grayish white color. The clay has no absorption. A sample of the clay has the following composition:

TABLE 45.

ANALYSIS OF MACLIN CLAY.

Moisture (H_2O)	.62
Volatile matter (CO_2, etc.)	7.02
Silicon dioxide (SiO_2)	64.88
Aluminum oxide (Al_2O_3)	20.70
Ferric oxide (Fe_2O_3)	4.19
Calcium oxide (CaO)	.69
Magnesium oxide (MgO)	.59
Sulphur trioxide (SO_3)	Trace
Total	98.69

RATIONAL ANALYSIS.

Clay substance	52.46
Free silica	33.10
Fluxing impurities	5.47

This clay and the four following clays may be classed as good potter's clay. It is possible that some of them may be refractory enough to be classed as fire clays since in a preliminary test two were not fused at the fusion point of Seger cone No. 20.

Brown Farm.—A pink clay from the J. T. Brown farm, south of Spring Hill. It is a plastic clay, having a specific gravity, ranging from 2.04 to 2.24. The air shrinkage of its brickettes is 8 per cent. The chemical composition of the clay is:

TABLE 46.

ANALYSIS OF BROWN CLAY.

Moisture (H_2O)	1.12
Volatile matter (CO_2, etc.)	9.22
Silicon dioxide (SiO_2)	55.87
Aluminum oxide (Al_2O_3)	30.19
Ferric oxide (Fe_2O_3)	2.44
Calcium oxide (CaO)	.53
Magnesium oxide (MgO)	.24
Sulphur trioxide (SO_3)	.23
Total	99.84

RATIONAL ANALYSIS.

Clay substance	76.51
Free silica	9.55
Fluxing impurities	3.21

This clay was unfused at the temperature required to fuse cone No. 20. It vitrified and turned gray in color at this temperature; it showed no absorption. Its physical properties seem to warrant its use as a ball clay.

Umbarger Farm.—A yellow plastic clay was collected on the Umbarger farm, five miles east of Canaan. The clay has the following chemical properties:

TABLE 47.

ANALYSIS OF UMBARGER CLAY.

Moisture (H_2O)	.23
Volatile matter (CO_2, etc.)	4.81
Silicon dioxide (SiO_2)	75.78
Aluminum oxide (Al_2O_3)	14.11
Ferric oxide (Fe_2O_3)	3.56
Calcium oxide (CaO)	.54
Magnesium oxide (MgO)	.52
Sulphur trioxide (SO_3)	.....
Total	99.55

RATIONAL ANALYSIS.

Clay substance	37.56
Free silica	54.13
Fluxing impurities	4.62

The clay is gritty to the taste and contains visible crystals of muscovite. The specific gravity is 2.35. The air dried brickettes shrink 4 per cent. This clay burned to a gray color at cone 20. It vitrified and had no absorption. The apex of the clay cone exhibited incipient viscosity at the above temperature. It may be utilized in the manufacture of stoneware.

Bonton Farm.—On the W. P. Bonton farm, five miles northeast of Canaan, there is an outcrop of pinkish-white clay. In water the clay slakes with moderate rapidity to a fine grain. The specific gravity is 2.23. The air shrinkage is 4 per cent. A chemical analysis of a sample of the clay gave the following results:

TABLE 48.

ANALYSIS OF BONTON CLAY.

Moisture (H_2O)	.98
Volatile matter (CO_2, etc.)	8.69
Silicon dioxide (SiO_2)	56.62
Aluminum oxide (Al_2O_3)	28.60
Ferric oxide (Fe_2O_3)	2.60
Calcium oxide (CaO)	.45
Magnesium oxide (MgO)	.24
Sulphur trioxide (SO_3)	.42
Total	98.46

RATIONAL ANALYSIS.

Clay substance	72.48
Free silica	12.44
Fluxing impurities	3.25

Doubtless this clay could be used to advantage as a ball clay.

Parham Farm.—A clay varying from white to cream in color occurs on the O. Parham farm, southeast of Michigan City. One sample of the clay gave a specific gravity of 2.10. The chemical properties of the clay are as follows:

TABLE 49.

ANALYSIS OF PARHAM CLAY.

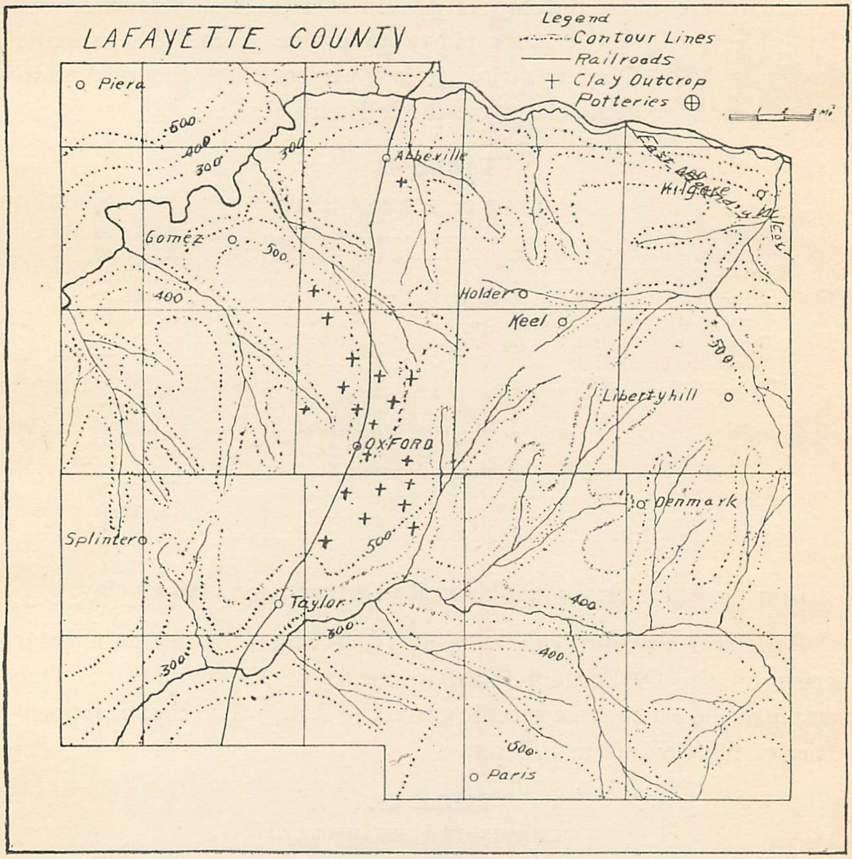
Moisture (H_2O)	1.09
Volatile matter (CO_2, etc.)	8.37
Silicon dioxide (SiO_2)	59.02
Aluminum oxide (Al_2O_3)	25.78
Ferric oxide (Fe_2O_3)	3.25
Calcium oxide (CaO)	.47
Magnesium oxide (MgO)	.24
Sulphur trioxide (SO_3)	.42
Total	98.64

Rational Analysis.

Clay substance	65.33
Free silica	19.47
Fluxing impurities	3.96

Clay was unfused at the temperature required to fuse cone No. 20. At this temperature the clay changed in color to a gray and vitrified. It shows no absorption at cone 20.

Plate XXVI.



LAFAYETTE COUNTY.

GEOLOGY.

Topography.—The larger part of Lafayette County is occupied by a highland area, the surface of which is about 500 feet above sea level. The Tallahatchie lowland lies in the northern part of the county at an elevation of about 200 feet lower than the central highland. The Yohnapatawpha lowlands occupy a portion of the southern part of the county. These lowlands have about the same elevation as those on the north. The greatest variation in altitude is something over 300 feet. The maximum recorded elevation is 458 feet at Oxford, and the lowest is 331 feet at Taylor. The valleys of even the smaller streams are deep, with moderately wide flat bottoms. On the divide southwest of Oxford there are some prominent buttes which may be seen from the highlands northeast of Oxford. These buttes are along the divide between the Tallahatchie and the Yohnapatawpha and are no doubt the highest elevations in the county.

Drainage.—The drainage of Lafayette County is accomplished by the Tallahatchie River and its branches. This river crosses the northwestern corner of the county and forms about fifteen miles of the northern boundary. It sends out numerous branches to drain the northern portion of the county. Among the more important of these branches are Tobi Tibby, Clear Creek, and Hurricane Creek. The southern part of the county is drained by the Yohnapatawpha River and its branches. The Yohnapatawpha flows into the Tallahatchie a few miles east of where the latter enters the Yazoo River.

Stratigraphy.—Lafayette County lies wholly within the area which the Wilcox formation occupies as a sub-formation. The Wilcox formation consists of beds of clay, sand and lignite. The sands are usually pink, red or yellow in color and very much cross-bedded. The clays are very frequently nearly pure white in color and often contain inclusions of lignite. The Wilcox rocks are very largely concealed by the more recent deposits of Lafayette and Columbia. The Lafayette is composed of sands and clays so similar in appearance to those of the Wilcox that the line of contact is difficult to mark in most places.

Transportation facilities.—The Illinois Central Railroad crosses Lafayette County in a north and south direction near the central portion of the county. This is the only line of railroad in the county at present, but there are many outcrops of white plastic clays at a convenient distance from this road. Especially is this true in the vicinity of Oxford. Many of the clays discussed in the following pages are near the railroad. A lack of railroad facilities is not a serious obstacle to the development of the clay industry in Lafayette County.

CLAYS AND CLAY INDUSTRY.

Oxford Court House Clay.—In the public road about three blocks east of the Oxford court house the following geological section is exposed:

4. Brownish loam....................................4 feet.
3. Red and white sand..............................6 feet.
2. White clay with bluish tint.........................1 foot.
1. White clay with yellow and pink tints..............4 feet.

The physical properties of a sample of white clay are as follows: The amount of water required to render the clay plastic is 30 per cent of the weight of the dry clay. The average tensile strength of the air dried brickettes is 35 pounds per square inch. The specific gravity of the clay is 2.46. The amount of air shrinkage is 6 per cent. The total shrinkage is 16 per cent. In firing the clay undergoes the following changes:

TABLE 50.

CHANGES IN OXFORD COURT HOUSE CLAY DURING FIRING.

Clay cone:				
Pyrometric cone	01	3	19	20
Color	pinkish white	pink	yellowish gray	gray
Hardness	soft	soft	steel hard	steel hard
Shrinkage	....	3	10	10
Absorption	17	15	....	....

The chemical composition of a sample of the clay is as follows:

TABLE 51.

ANALYSIS OF OXFORD COURT HOUSE CLAY.

Moisture (H_2O)	.69
Volatile matter (CO_2, etc.)	8.20
Silicon dioxide (SiO_2)	60.00
Aluminum oxide (Al_2O_3)	27.80
Ferric oxide (Fe_2O_3)	.75
Calcium oxide (CaO)	1.38
Sulphur trioxide (SO_3)	.20
Total	99.02

RATIONAL ANALYSIS.

Clay substance	70.45
Free silica	17.35
Fluxing impurities	2.35

A number of mixtures of the Oxford clay, with small percentages of other clays and of grog, were made after the following manner: The clays were ground and passed through a 100-mesh sieve. The

Plate XXVII.

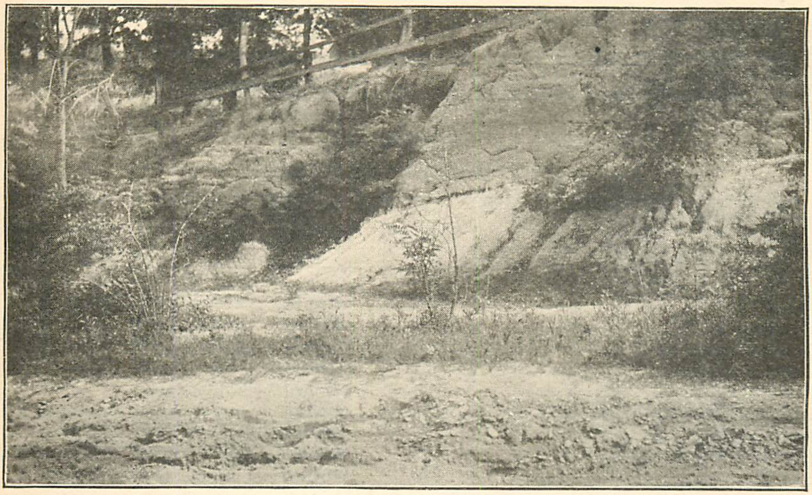


Figure 1. WILCOX WHITE CLAY EAST OF THE COURT HOUSE AT OXFORD.

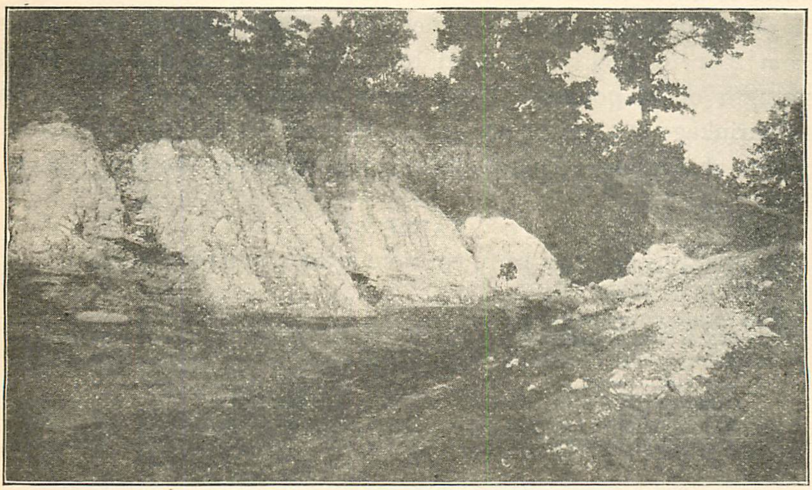


Figure 2. WILCOX CLAY ON THE WIGGINS FARM SOUTHEAST OF OXFORD.

clays were then mixed and molded into small brickettes. Some of the brickettes were dipped into a slip of the Albany clay for glazing. They were then burned at the temperature required to fuse cone 20. The following table exhibits the results obtained:

TABLE 52.

OXFORD CLAY MIXTURES.

Clay	*Per Cent*	*Hardness*	*Color*	*Glaze*	*Imperfections*
Casselberry	10	vitrified	brown	good	none
Penniwinkle	10	vitrified	cream	good	none
Brown, Tilman	10	vitrified	white	good	none
Casselberry	25	vitrified	cream	good	none
Penniwinkle	25	vitrified	white	good	none
Brown, Tilman	25	vitrified	yellow	good	none
Burned brick	10	vitrified	yellow	good	none
Burned brick	25	vitrified	yellow	good	none
Burned brick	40	vitrified	yellow	good	none

Colored school building, Oxford.—A sample of clay was collected from a point in the street near the colored school building in Oxford. The prevailing colors of the clay in the outcrop are pink, yellow, and white. In the powdered form the color is cream. It slakes slowly in water to a fine flake. The amount of water required for plasticity is 25 per cent of the weight of the clay. The specific gravity ranges from 2.31 to 2.56. Air dried brickettes have an average tensile strength of 48 pounds. These shrink in drying 7 per cent. The air shrinkage is about 5 per cent. At cone 20 the clay is hard and has no absorption. The chemical composition of the clay is as follows:

TABLE 53.

ANALYSIS OF CLAY FROM COLORED SCHOOL BUILDING, OXFORD.

Moisture (H_2O)	1.14
Volatile matter (CO_2, etc.)	9.11
Silicon dioxide (SiO_2)	57.79
Aluminum oxide (Al_2O_3)	26.03
Ferric oxide (Fe_2O_3)	2.98
Calcium oxide (CaO)	.44
Magnesium oxide (MgO)	.10
Sulphur trioxide (SO_3)	.24
Total	92.93

RATIONAL ANALYSIS.

Clay substance	65.97
Free silica	17.85
Fluxing impurities	3.52

This clay burns to a nearly white body. The ware becomes firm, compact and hard at red heat. Burns without checking or cracking. Is easily molded into any desired form and may be considered a good clay for potters' use.

Brunner Farm.—In a small run on the Brunner farm, two and one-half miles northeast of Oxford, the following section is exposed:

4. Reddish, unstratified sand	30 feet.
3. Stratified red sand with white partings	10 feet.
2. Laminated pink, yellow, and white clay	4 feet.
1. Cross-bedded, micaceous sand	4 feet.

Near the top the first member of the section contains ironstone concretions and the fragments of irregular layers of ironstone. A sample of the clay from number 3 exhibited the following physical characteristics: Slightly gritty to the taste and feel; slakes rapidly to medium grain; requires one-fourth its weight of water to render it plastic. The average tensile strength is 20 pounds per square inch. The air shrinkage is 2 per cent. Muscovite crystals are visible to the naked eye, but pyrite or other deleterious substances are not present. The average specific gravity is 2.34.

A grayish sandy fire clay from the same locality as the preceding has the following chemical properties:

TABLE 54.

ANALYSIS OF BRUNNER CLAY.

Moisture (H_2O)	1.16
Volatile matter (CO_2, etc.)	2.84
Silicon dioxide (SiO_2)	70.35
Aluminum oxide (Al_2O_3)	18.61
Ferric oxide (Fe_2O_3)	1.86
Calcium oxide (CaO)	.51
Magnesium oxide (MgO)	.10
Sulphur trioxide (SO_3)	.24
Total	95.67

RATIONAL ANALYSIS.

Clay substance	47.18
Free silica	41.78
Fluxing impurities	2.47

The clay becomes plastic when mixed with about 16 per cent of water. The specific gravity varies from 2.45 to 2.64. The air dried brickettes have an average tensile strength of 115 pounds per square inch. They shrink in drying 2 per cent.

Uses.—The Brunner clay can be utilized in the manufacture of a general line of stoneware. The raw clay receives both the artificial glaze and the natural clay glaze applied as a slip.

Tubbs Farm.—A pinkish white clay was collected from the Tubbs farm, three miles south of Oxford. An analysis of a sample gave the following results:

TABLE 55.

ANALYSIS OF TUBBS CLAY.

Moisture (H_2O)	.90
Volatile matter (CO_2, etc.)	8.35
Silicon dioxide (SiO_2)	60.40
Aluminum oxide (Al_2O_3)	27.68
Ferric oxide (Fe_2O_3)	1.32
Calcium oxide (CaO)	1.08
Magnesium oxide (MgO)	.....
Sulphur trioxide (SO_3)	.....
Total	99.73

RATIONAL ANALYSIS.

Clay substance	70.15
Free silica	17.93
Fluxing impurities	2.40

This clay has a specific gravity of 2.41 to 2.58. In water it slakes readily to flakes of medium size. The air dried brickettes have an average tensile strength of 38 pounds per square inch. They shrink in air drying 2 per cent. The amount of water required to render the clay plastic is one-third of its weight To the taste the clay is very slightly gritty. To the feel it is unctious.

Uses.—The Tubbs clay is a good grade of ball clay which may be used for pottery or stoneware purposes. The natural clay applied as a slip forms a good glaze when applied to the surface of the raw clay.

Wiggins Farm.—On the James Wiggins farm, two and one-half miles southeast of Oxford, there is an outcrop of white plastic clay which forms the basal member of the following section:

4. Soil	5 feet.
3. Reddish brown sand (Lafayette)	10 feet.
2. Yellowish clay with thin iron stone partings	3 feet.
1. White clay	4 feet.

There is a decided unconformity between numbers 2 and 3 near this point. This unconformity probably marks the line of separation for the Lafayette and the Wilcox. The white clay of number 4 is unctious and on'y slightly gritty to the taste. The specific gravity ranges from 2.26 to 2.45. The air dried brickettes have an average tensile strength of 36 pounds. The air shrinkage is 4 per cent. It requires 25 per cent of water to make it plastic. The chemical composition of the clay is as follows:

TABLE 56.

ANALYSIS OF WIGGINS CLAY.

Moisture (H_2O)	.96
Volatile matter (CO_2, etc.)	6.41
Silicon dioxide (SiO_2)	68.20
Aluminum oxide (Al_2O_3)	17.48
Ferric oxide (Fe_2O_3)	1.86
Calcium oxide (CaO)	.65
Magnesium oxide (MgO)	.21
Sulphur trioxide (SO_3)	.12
Total	95.89

RATIONAL ANALYSIS.

Clay substance	44.32
Free silica	41.36
Fluxing impurities	2.72

Russel Farm.—This clay is on the Russel farm, one-half mile east of Brunner clay. The outcrop consists of 6 feet of variegated clay covered by 20 feet or more of reddish sand. A spring occurs on the slope of the hill at the point of contact of the clay and sand. The upper member has all the characteristics of the Lafayette. The geological position of the lower member is uncertain, but is probably Wilcox.

The following is the chemical composition of a sample of the clay:

TABLE 57.

ANALYSIS OF RUSSEL CLAY.

Moisture (H_2O)	1.16
Volatile matter (CO_2, etc.)	10.14
Silicon dioxide (SiO_2)	51.88
Aluminum oxide (Al_2O_3)	30.64
Ferric oxide (Fe_2O_3)	3.53
Calcium oxide (CaO)	.58
Magnesium oxide (MgO)	.60
Total	98.53

RATIONAL ANALYSIS.

Clay substance	77.65
Free silica	4.87
Fluxing impurities	4.71

This clay is noticeable for its high percentage of clay substance and its low percentage of sandy matter. It is very plastic when mixed with 32 per cent of water. White and pink are the prevailing colors. The average tensile strength is 35 pounds per square inch. Its specific gravity ranges from 2.42 to 2.51. In water it slakes rapidly to medium size flakes. The air shrinkage is 5 per cent, and the fire shrinkage is 2 per cent. The unglazed product of the kiln is hard and firm and cream in color. At cone 20 the clay turned gray and vitrified. It exhibited no absorption. The clay is unquestionably a desirable one for stoneware purposes.

Wiley Farm.—A yellow to buff colored clay was collected from the Wiley farm, six miles southeast of Oxford. It is a plastic clay containing muscovite crystals of microscopic size. The average specific gravity is 2.24. The air shrinkage of brickettes made from finely ground clay is 4 per cent. The following is the chemical composition:

TABLE 58.

ANALYSIS OF WILEY CLAY.

Moisture (H_2O)	1.64
Volatile matter (CO_2, etc.)	8.99
Silicon dioxide (SiO_2)	57.48
Aluminum oxide (Al_2O_3)	26.94
Ferric oxide (Fe_2O_3)	2.43
Calcium oxide (CaO)	.78
Magnesium oxide (MgO)	.27
Sulphur trioxide (SO_3)	.20
Total	98.73

RATIONAL ANALYSIS.

Clay substance	68.27
Free silica	16.15
Fluxing impurities	.48

Another clay from the same locality is light yellow to white in color. It has a specific gravity of 2.30. Slakes readily in water to fine grain. The average tensile strength is 35 pounds per square inch. The air shrinkage is 5 per cent.

A clay similar to the above occurs on the Sisk farm, three miles southeast of Oxford (Sec. 10, T. 9, R. 3, W.) Some of its physical characters are as follows: The specific gravity is 2.59. It becomes plastic when mixed with 25 per cent of water. The average tensile strength is 45 pounds per square inch. The air dried brickettes shrink 6 per cent. Pale pink and white are the prevailing colors.

Callicott Farm.—An outcrop of white clay is found on the Callicott farm, in the next section south of the one mentioned. This clay has the following chemical composition:

TABLE 59.

ANALYSIS OF CALLICOTT CLAY.

Moisture (H_2O)	.90
Volatile matter (CO_2, etc.)	6.17
Silicon dioxide (SiO_2)	68.75
Aluminum oxide (Al_2O_3)	19.57
Ferric oxide (Fe_2O_3)	1.68
Calcium oxide (CaO)	.56
Magnesium oxide (MgO)	.19
Sulphur trioxide (SO_3)	.13
Total	97.95

RATIONAL ANALYSIS.

Clay substance	49.59
Free silica	38.73
Fluxing impurities	2.43

The physical properties of the clay are: Specific gravity, 2.17; air shrinkage, 4 per cent; average tensile strength, 30 pounds per square inch. The amount of water required is 25 per cent of the weight of the clay. Another sample of clay taken from the same locality is of a pinkish white color. It has a specific gravity of 2.57. The average tensile strength is 45 pounds per square inch. Its air shrinkage is 5 per cent. On the next section west is a white clay having a specific gravity of 2.53. It is plastic when mixed with one-fourth its weight of water. It shrinks 4 per cent in drying.

Uses.—The Callicott clay can be used in the manufacture of stoneware. When the Albany slip clay is applied to the body and then burned it forms a good glaze.

Moss Farm.—A lavender colored clay was collected from the Moss farm, about three miles northwest of Oxford. The chemical analysis of a sample of this clay gave the following results:

TABLE 60.

ANALYSIS OF MOSS CLAY.

Moisture (H_2O)	.63
Volatile matter (CO_2, etc.)	6.66
Silicon dioxide (SiO_2)	70.56
Aluminum oxide (Al_2O_3)	19.03
Ferric oxide (Fe_2O_3)	2.27
Calcium oxide (CaO)	.49
Magnesium oxide (MgO)	.13
Sulphur trioxide (SO_3)	.19
Total	99.96

RATIONAL ANALYSIS.

Clay substance	48.23
Free silica	41.36
Fluxing impurities	2.89

This clay becomes plastic when mixed with 25 per cent of water. The specific gravity is 2.45. The air shrinkage is 6 per cent. Another sample of clay taken from the same locality has visible muscovite crystals. The color of the clay varies from light yellow to cream. The specific gravity of one sample was 2.35. It becomes plastic when mixed with 30 per cent of water. At cone 20 this clay was gray in color and vitrified. It exhibited no absorption.

Uses.—The Moss clay may be classed as a stoneware clay.

Miller Farm.—This clay is from the Miller farm, five miles northwest of Oxford. It is a grayish white clay containing a high per cent of silica. It is gritty to the taste and the feel. It contains a high percentage of microscopic quartz grains. The average tensile strength of its air dried brickettes is 90 pounds per square inch. They shrink in drying 4 per cent. The chemical properties are as follows:

TABLE 61.

ANALYSIS OF MILLER CLAY.

Moisture (H_2O)	.73
Volatile matter (CO_2, etc.)	2.37
Silicon dioxide (SiO_2)	85.78
Aluminum oxide (Al_2O_3)	6.68
Ferric oxide (Fe_2O_3)	1.30
Calcium oxide (CaO)	.47
Magnesium oxide (MgO)	.14
Sulphur trioxide (SO_3)	.32
Total	97.80

RATIONAL ANALYSIS.

Clay substance	16.93
Free silica	75.53
Fluxing impurities	1.92

Uses.—The Miller clay exhibits all the properties essential for a good pottery clay. It receives both the artificial and the natural glaze.

Northeast of Oxford.—In the public road three and one-half miles northeast of Oxford there is a white clay with pink or yellow tints in some layers. The physical properties of the clay are: Specific gravity ranging from 2.38 to 2.47; average tensile strength, 55 pounds per square inch. In water it slakes slowly to medium grains. When mixed with 33 per cent of water and air dried it shrinks 6 per cent.

Plate XXVIII.

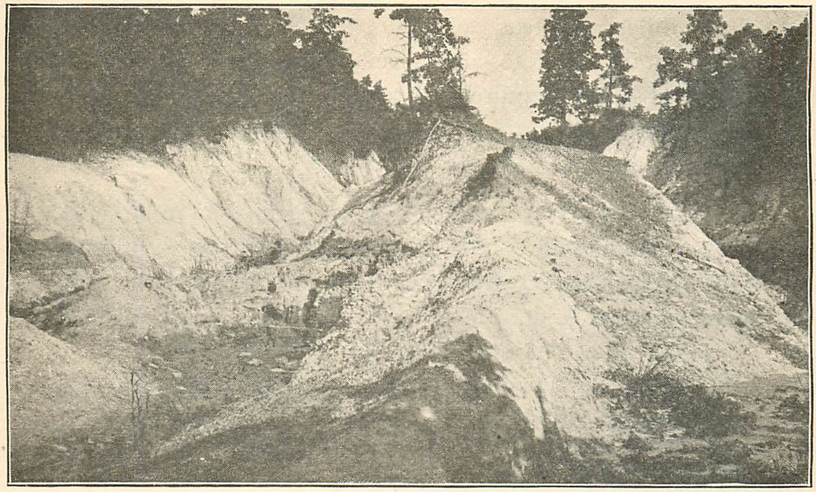


Figure 1. WILCOX CLAY STRIPPED OF OVER-BURDEN BY EROSION, BARRY PLACE, NORTH OF OXFORD.

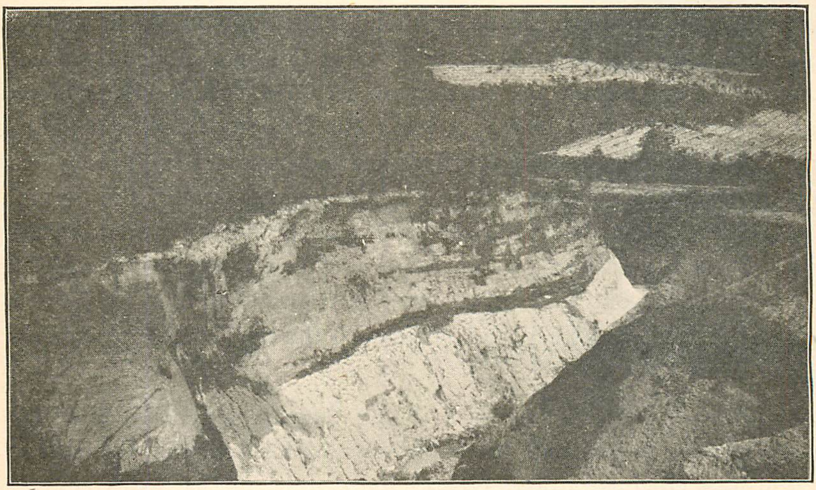


Figure 2. GULCH ON THE COHRN FARM, SOUTH OF OXFORD, WILCOX CLAY IN BOTTOM.

Crouch Farm.—This is a light brown clay occurring on the Crouch farm, three miles northeast of Oxford. The clay contains many muscovite crystals of microscopic size. The specific gravity is 2.48. The amount of water required to render it plastic is 32 per cent. The average tensile strength of the clay is 53 pounds per square inch. In air drying it shrinks 5 per cent.

Other ocalities.—White pottery clays occur one mile north of Oxford in the public road; on the Barry place about three miles north; at the four-mile post; five miles north on the College Hill road; six miles north on John Anderson farm; seven miles north on Fernanez farm; one-half mile west of College Hill on Tankersley farm; southeast of Oxford on the Washington farm, on the Cohrn farm, and on the Coleman farm.

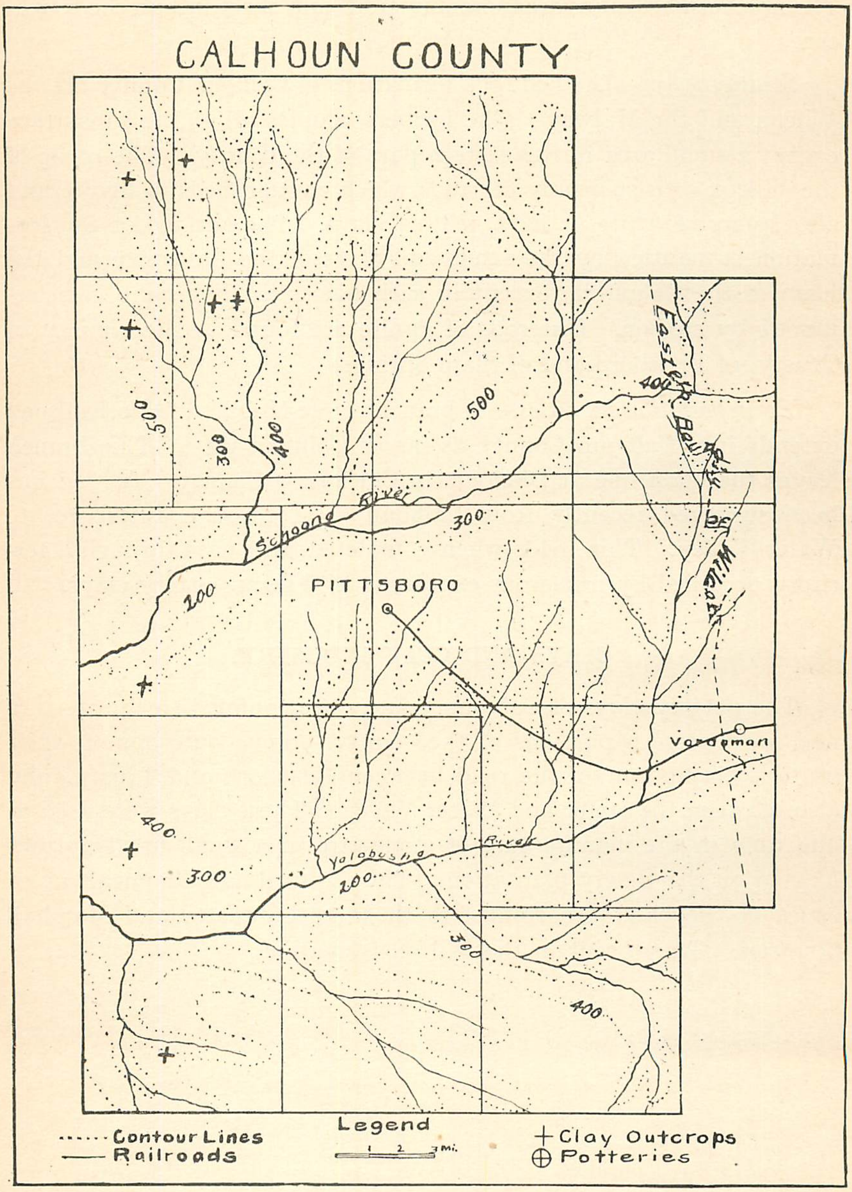
CALHOUN COUNTY.

GEOLOGY.

Topography.—The surface of Calhoun County may be divided into four topographic regions. The northern portion of the county is occupied by a plateau like area having an altitude of 500 feet above sea level. To the south of this high land is the Schoona River Valley, which lies some 200 feet below the level of the high land. South of Schoona River the surface rises again to form the divide between that river and the Yalobusha, of which the Schoona River is a tributary. The Yalobusha Valley, which lies south of this high land, has an altitude about 200 feet lower than the highest part of the divide. South of the Yalobusha Valley the surface of the county rises to higher land. Even the smaller streams have comparatively broad valleys, and their level condition gives one the impression that they have been partly refilled. These valleys furnish the best agricultural lands of the county.

Drainage.—The drainage of Calhoun County is accomplished by the Yalobusha River and its tributaries. The Schoona River, the Yalobusha's chief tributary, crosses the county in the north central portion. The Schoona sends off very few branches toward the south, but northward it sends off numerous branches into the northern highlands. The Yalobusha River traverses the southern part of the county

PLATE XXIX.



CALHOUN COUNTY
Schoona River
PITTSBORO
Vardaman
Yalobusha River
500
300
400
100
200
Contour Lines
Railroads
Legend
1 2 3 Mi.
Clay Outcrops
Potteries

flowing from east to west. Branches are sent off both north and south. The northern branches are more numerous and shorter than the southern.

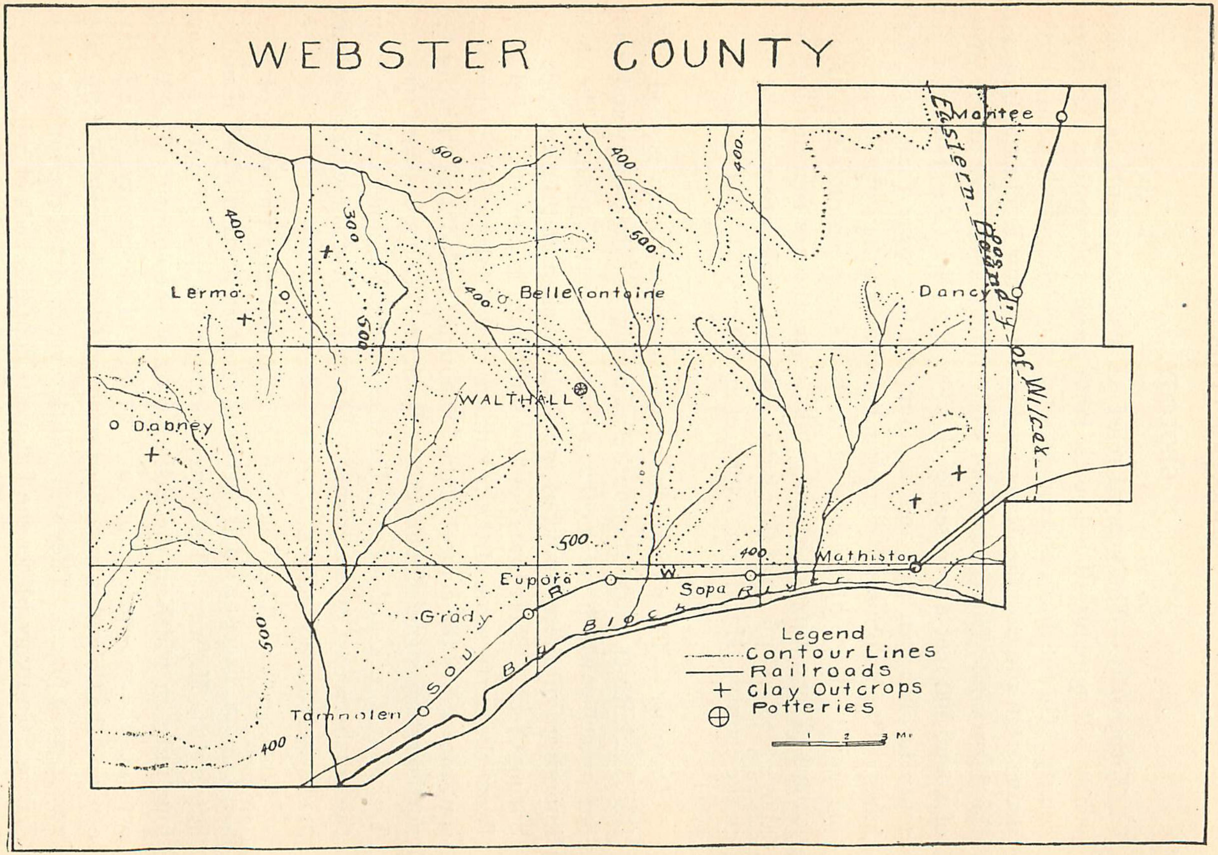
Stratigraphy.—The bed rock formations of Calhoun County are the Wilcox and the Midway. The former occupies all of the subsurface except a small area in the eastern part of the county The rocks of the Wilcox consist mostly of sands which contain beds of lignite and also layers of white or light colored clays. The surface of the formation is mantled by the sands and clays of the Lafayette and the loam of the Columbia, except in such places as they have been removed by erosion. Outcrops of lignite are found in the vicinity of Trusty, of Pittsboro and of Slate Springs.

Transportation facilities.—A branch of the Mobile & Ohio Railroad extends into Calhoun County as far as Calhoun City. This branch leaves the main line at Okolona, in Chickasaw County. A road has been surveyed recently from Calhoun City, through Pittsboro, to Water Valley. This road, when completed, will pass through a territory occupied by numerous exposures of Wilcox pottery clays.

CLAYS AND CLAY INDUSTRY.

The pottery clays of Calhoun County are confined to the western and northwestern portions of the county. Some outcrops of white potter's clay occur on the road between Pittsboro and Trusty, and also between the latter and Water Valley. These clays were used at one time in the manufacture of stoneware in a small hand pottery located on the Ersery plantation. The physical and chemical properties of the clays are similar to those of Lafayette and Marshall Counties. They occur in the Wilcox formation.

PLATE XXX



WEBSTER COUNTY
Maritee
Eastern Boundary of Wilcox
Dancy
Lermo
Bellefontaine
WALTHALL
Dabney
Mathiston
Eupora
Sopa
Grady
Tomnolen
Big Black River
SOU
R
W
300
400
500
Legend
Contour Lines
Railroads
Clay Outcrops
Potteries
1
2
3 Mi

WEBSTER COUNTY.

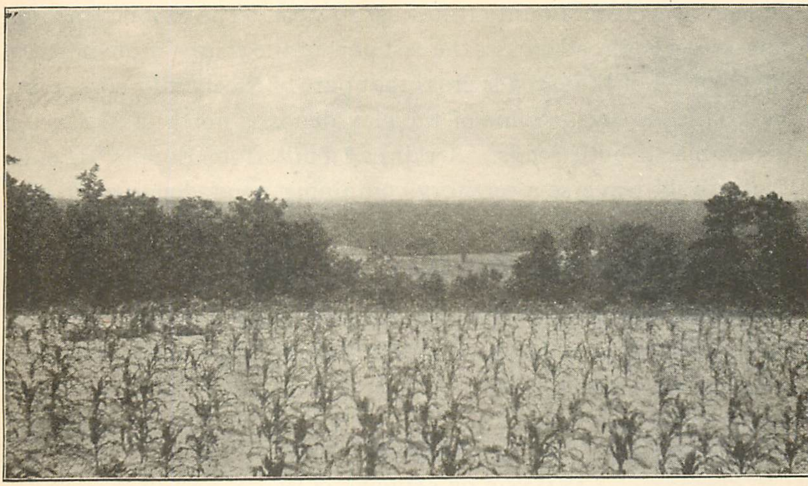
GEOLOGY.

Topography.—The general relief of Webster county is that of a gently rolling plain. The highest lands are in the western part of the county. On the north and on the south the highlands descend to river plains. On the east the descent is made to a low level area known as the flatwoods. The central and western highlands have an elevation of about 500 feet above sea level. The Big Black River plain on the south lies between one and two hundred feet lower than these high lands. The Yalobusha River plain lies at about the same elevation on the north. The extreme crest of the divide between these two streams is marked by a range of irregular hills, rising three or four hundred feet above the flood-plains of the rivers. Only a few elevations are recorded in the county. Mathiston is 405 feet and Dancy 312 feet above the sea level.

Drainage.—The natural drainage of Webster County is good. The Big Black River marks the southern boundary of the county and sends out branches which cut northward into the central plain. The most important of these branches are Wolf Creek, Calabretta Creek and Spring Creek. These branches flow southward in almost parallel lines. From the north some of the tributaries of the Yalobusha River extend southward into the central plain. Sabougla Creek drains a part of the northwestern corner of the county. Buck Creek, Shootaspear Creek and Tapashaw Creek are other tributaries of the Yalobusha, which drain the northern part of the county. The majority of these streams have moderately broad valleys.

Stratigraphy.—The Wilcox formation underlies the whole of Webster County, except a small part of the eastern portion which is underlain by the Midway. The latter occupies an area of outcrop about four miles in width in the eastern part of the county. The Wilcox occupies the sub-surface for the remainder of the county. The Lafayette and the Columbia have been removed from the surface of the Midway in most places. They still mantle a great part of the surface of the Wilcox. In many places the Lafayette contains beds of iron-stone of irregular distribution and thickness. The range of hills in the divide west of Mantee, contain such rocks.

PLATE XXXI.



A. VIEW SHOWING THE TOPOGRAPHY OF THE WILCOX AREA WEST OF MANTEE, WEBSTER COUNTY.

B. POND MADE IN THE FLATWOODS CLAY AT MANTEE, WEBSTER CO.

Transportation facilities.—The Southern Railroad traverses the south part of Webster County from east to west. The Mobile, Jackson & Kansas City Railroad crosses the east part of the county from north to south. Neither of these roads cross that part of the county containing the best Wilcox clays. Some of the clay deposits north of Mathiston are accessible to both roads. A railroad built from Eupora through Walthall would traverse a territory containing good deposits of pottery clays.

CLAYS AND CLAY INDUSTRY.

Sanders farm.—A gray clay was collected from the farm of B. F. Sanders, about three miles north of Mathiston. The chemical composition of the clay is as follows:

TABLE 62.

ANALYSIS OF SANDERS CLAY.

Moisture (H_2O)	1.47
Volatile matter (CO_2, etc.)	9.24
Silicon dioxide (SiO_2)	59.82
Aluminum oxide (Al_2O_3)	27.19
Ferric oxide (Fe_2O_3)	1.26
Calcium oxide (CaO)	.49
Magnesium oxide (MgO)	.37
Sulphur trioxide (SO_3)	.31
Total	100.15

RATIONAL ANALYSIS.

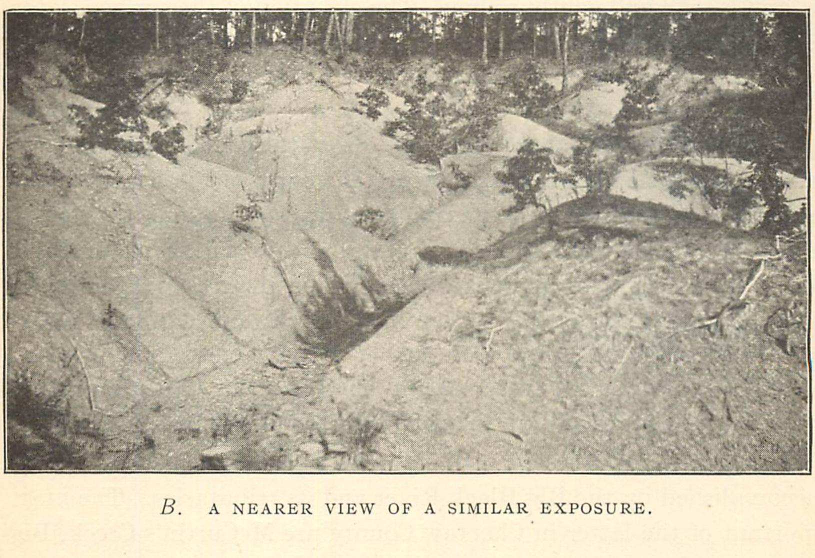
Clay substance	68.80
Free silica	18.21
Fluxing impurities	2.43

The clay slakes very slowly to fine grain. It has a specific gravity of 2.51. The tensile strength is 68 pounds for the average and 81 pounds for the maximum. The amount of water required to render it plastic is 25 per cent. The air shrinkage is 6 per cent. At cone 20, the clay vitrifies and turns dark gray. It is without absorption. The ware has a good strong body, but shows small spots of iron which would not be present if the clay was ground before mixing. The brown slip glaze is used.

For a number of years Mr. J. P. Thomas used this clay at Cumberland, in the manufacture of stoneware. The clay was mixed with one of lighter color from near Clarkson. He manufactured about 2,000 gallons of jugs, jars and churns. The pottery is not now in operation.

Plate XXXII.

A. TYPICAL EROSION IN FLATWOODS CLAY AT MANTEE, WEBSTER COUNTY.



B. A NEARER VIEW OF A SIMILAR EXPOSURE.

Mathiston clay.—In the public road, about three and one-half miles north of Mathiston, there is an outcrop of white clay, which on exposed surfaces, is considerably indurated. The plasticity of the underground clay is poor, but the plasticity increases with the fineness of the grain. The specific gravity is 2.31. In water the clay slakes slowly to fine grain. The average tensile strength of its air-dried brickettes is 25 pounds per square inch. It requires 35 per cent of water for plasticity. In air-drying it shrinks 4 per cent. At the temperature necessary to fuse cone 6 there was no further shrinkage. At this point the clay became vitrified and presented a firm white body without spots, erazing, or checks.

Other localities.—Pottery clays occur in the western part of the county in the neighborhood of Dabney and also near Lerma. Outcrops of lignite also occur in this portion of the county.

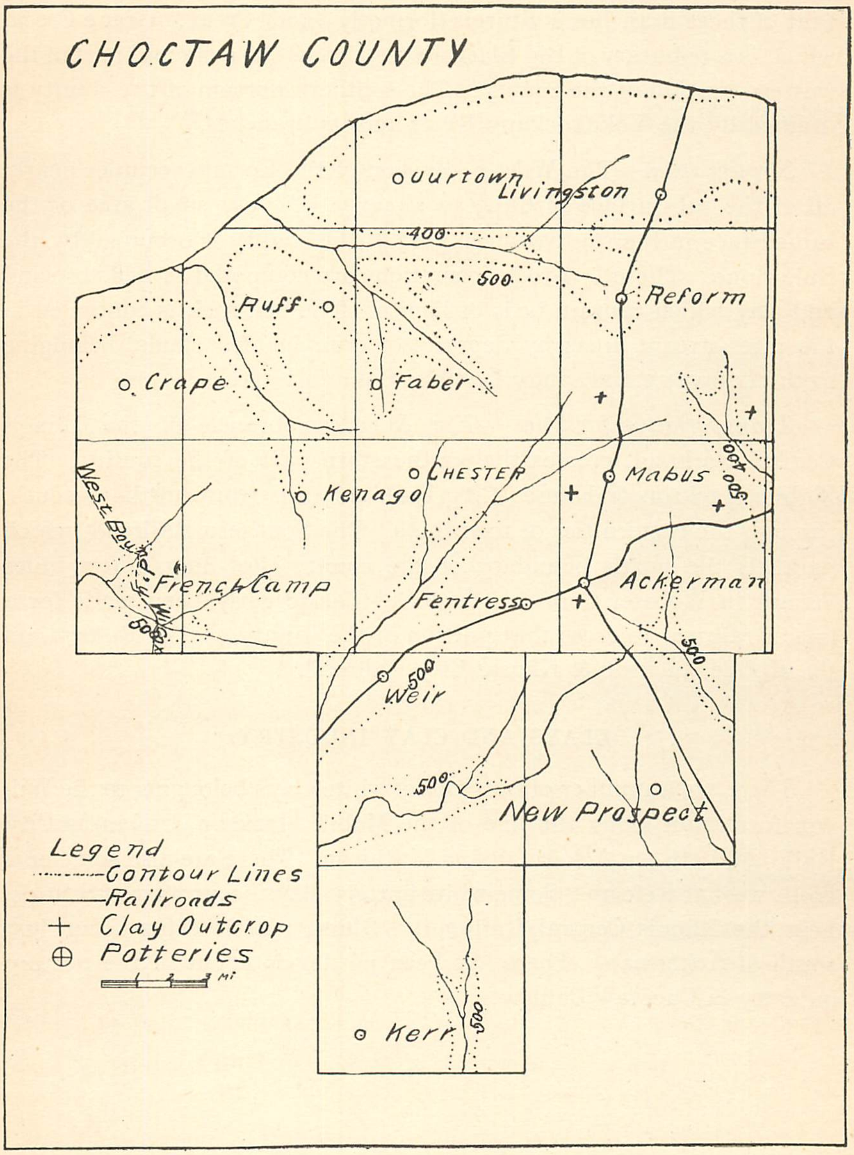
CHOCTAW COUNTY.

GEOLOGY.

Topography.—Choctaw County lies mainly in the plateau-like area which separates the Tombigbee River system on the east, from the Black River and the Pearl River systems on the west. The surface of the land is high and gently rolling. The elevation of the surface is, for the most part, between 500 and 600 feet above sea level. The streams have cut moderately deep trenches in its borders and are as a rule, bordered by moderately broad flood-plain areas. The maximum variation in altitude is about 300 feet. From the central highland the surface descends to the low land along the course of the Black River, where the lowest altitude of the county is reached. Along the line of the Mobile Jackson & Kansas City Railroad the surface of the land rises to reach its highest point at Sherwood, on the crest of the divide. From Sherwood the surface descends southward toward Yokahockany River, which is a tributary of Pearl River. The highest recorded elevation is 547 feet at Blanton's Gap. The lowest elevation for the county is probably in the neighborhood of 400 feet.

Drainage.—The drainage of the northern part of Choctaw County is accomplished by the Big Black River and its tributaries. The most important of the latter in Choctaw County are McCurtin's Creek, Big Bywian and Pigeon Roost. The latter has a flood-plain over a mile in

PLATE XXXIII.



width, near Mathiston. The eastern and southeastern parts of the county are drained by branches of Noxubee River. The most important of these branches is Sturgis (formerly Sand) Creek. Grape Creek, which is a tributary of Big Black River, drains the principal part of the western portion of the county. The southern portion of the county is drained by the Yokahockany River and its branches.

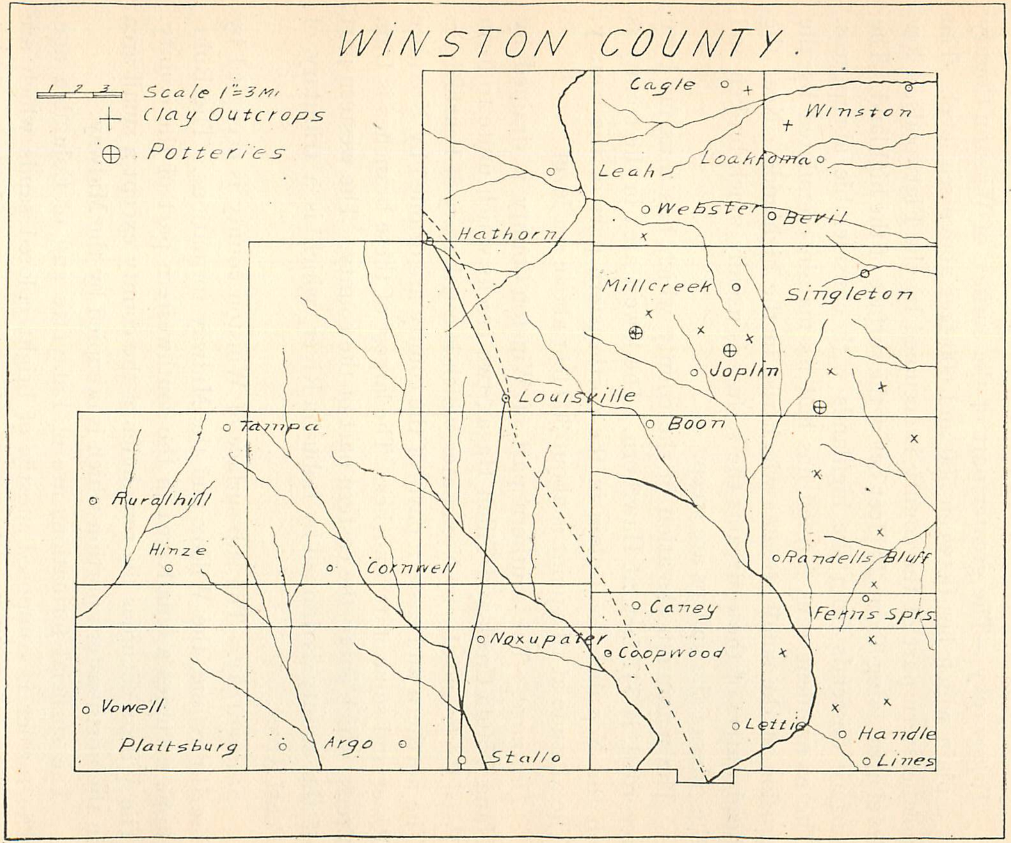
Stratigraphy.—The Wilcox division of the Eocene occupies nearly all of the sub-surface of Choctaw County. A very small area of the sub-surface in the southwestern part of the county is occupied by the Buhrstone. These bed-rock formations are composed of beds of sand and clay which contain beds of lignite. The bed-rock is concealed in the inter-stream areas by deposits of cross-bedded sands, belonging to the Lafayette and sandy loams of Columbia age.

Transportation facilities.—The Aberdeen branch of the Illinois Central Railroad, crosses the southeastern part of the county. The Mobile, Jackson & Kansas City Railroad runs from north to south, through the eastern tier of townships. The Southern Railroad, which parallels the north boundary of the county, lies only a few miles distant in Webster County. A survey has recently been made for a line of railroad to cross that portion of the county east of Reform, on the Mobile, Jackson & Kansas City Railroad.

CLAYS AND CLAY INDUSTRY.

There are a number of outcrops of white clays belonging to the Wilcox formation along the line of the Mobile, Jackson & Kansas City Railroad, between Ackerman and Mathison. There are also some outcrops west of Reform. Some white pottery clays occur west of Sturgis, near the Illinois Central Railroad. Bluish plastic clays occur just south of Ackerman. There has been no development of the pottery industry in Choctaw County.

PLATE XXXIV.


WINSTON COUNTY.
Scale 1"=3 Mi
Clay Outcrops
Potteries
Cagle
Winston
Leah
Loakfoma
Webster
Beril
Hathorn
Millcreek
Singleton
Joplin
Louisville
Boon
Tampa
Ruralhill
Hinze
Cornwell
Randells Bluff
Caney
Ferns Sprs.
Noxupater
Coopwood
Vowell
Plattsburg
Argo
Stallo
Lettie
Handle
Lines

WINSTON COUNTY.

GEOLOGY.

Topography.—The greater part of the surface of Winston County is a plain which lies between 500 and 600 feet above sea level. The northeastern part of the county is occupied by the Flatwoods, a low level area, lying about 200 feet below the surface of the highland. The surface descends from the highlands with considerable abruptness. The escarpment thus formed has had its margin crenulated by the erosion of the small streams which rise in the highlands. Near the head-waters of these streams the surface is usually much broken and the sides of the valleys are steep.

The maximum elevation in the county which has thus far been recorded, is 547 feet, at Hawthorn. The lowest area in the county is on the Noxubee flood-plain in the northeastern part of the county. The altitude at this point is about 300 feet above sea level.

Drainage.—The southern part of Winston County is drained by Nana Waufa Creek and Tillah Hagal, two creeks which unite to form Pearl River and also by Noxupater, which is a tributary of Pearl River. The northern and eastern parts of the county are drained by Noxubee River and some of its branches. The largest of these branches is Linn Creek, which enters the eastern part of the county. The western part of the county is drained by Lobucha River, which is a tributary of Pearl River.

Stratigraphy.—The sub-surface of Winston county is occupied by the Buhrstone, the Wilcox and the Midway formations. The Buhrstone occupies a small area in the southwestern part of the county. The Wilcox occupies the remainder of the county except a small area in the northeastern portion which is occupied by the Midway.

The surficial formations are of Lafayette and of Columbia age. The former is composed mostly of bright colored sands which are usually cross-bedded and contain clay partings and clay pebbles. There are few gravels in the Lafayette of Winston county. The Columbia consists of a yellow loam.

Transportation facilities.—Winston County is crossed near its central part by the Mobile, Jackson & Kansas City Railroad which extends in a north and south direction. The best pottery clays are exposed on the east side of the county which is at present, without railroad transportation. Better transportation facilities for this part of the county will be accompanied by increased development of the clay industry. For when the quality of the clay is considered, it is not unreasonable to expect that with increased railroad facilities, some of the small hand potteries will be replaced by steam potteries.

CLAYS AND CLAY INDUSTRY.

Eiland plantation.—On the old Eiland plantation, one mile south of the house of Mr. J. A. M. Loyd, on the Macon road, the following section is exposed:

2. Lafayette sand and clay	4 feet.
1. Clay of various tints	15 feet.

A few rods south, another section is exposed:

5. Lafayette sand and clay	6 feet.
4. Blue clay	4 feet.
3. Lignite	3 feet.
2. Blue clay containing vegetable matter	6 feet.
1. Clay and ironstone in thin layers	4 feet.

All but number one of the second section is below the first section. Number two of the first section varies in color and texture in the various layers which compose it. Mr. J. A. M. Loyd, who has used the clay from this outcrop in the manufacture of stoneware, says, that he obtains the best results by mixing the clay from a two-foot layer at the bottom with the clay from a three-foot layer near the top.

The chemical analysis of a sample from the three-foot layer is as follows:

TABLE 63.

ANALYSIS OF LOYD CLAY.

Moisture (H_2O)	.47
Volatile matter (CO_2, etc.)	9.24
Silicon dioxide (SiO_2)	59.82
Aluminum oxide (Al_2O_3)	27.19
Ferric oxide (Fe_2O_3)	1.26
Calcium oxide (CaO)	.49
Magnesium oxide (MgO)	.37
Sulphur trioxide (SO_3)	.31
Total	99.35

RATIONAL ANALYSIS.

Clay substance	68.90
Free silica	18.11
Fluxing impurities	2.12

At cone 20 the clay burned to a gray color, vitrified and exhibited no absorption.

This clay makes a good quality of stoneware, when even the crude methods of the hand potter are employed. That with better methods and machinery, the quality of the ware would greatly increase, there can be little doubt.

Stewart clay pit.—A sample of clay from the Homer Stewart clay pit, on the Macon-Louisville road, about a quarter of a mile east of the Stewart pottery. It is a yellowish-white clay, with yellow and purple blotches and changes to cream color when powdered and dampened. It requires 30 per cent of water to render it plastic and shrinks 4 per cent in drying. The average tensile strength is 45 pounds per square inch. The specific gravity is 2.42. Mr. Homer Stewart uses this clay in the manufacture of jugs, churns, jars and crocks. He uses an up-draught kiln with a capacity of 500 gallons. His present output is about 4,000 gallons per year. He uses the Albany slip clay for glazing puposes. The clay becomes vitrified between cones 5 and 6. The color of the ware is light red or cream. Its body is firm and strong.

Ellis farm.—A clay similar to the Stewart clay outcrops near a creek bed on the Ellis farm, one-half mile south of the Stewart pottery. It is a tinted clay in which the predominant colors are white and yellow. In water it slakes readily to a medium grain. The specific gravity ranges from 2.36 to 2.61. The average tensile strength of its air-dried brickettes is 60 pounds per square inch. The amount of water required for plasticity is 30 per cent and the shrinkage is 5 per cent. It may be classed as a stoneware clay of good quality. The fire shrinkage is about 2 per cent. The color of the burnt clay is variable from white to light yellow.

Fern Springs.—There is an outcrop of white potters' clay near the public road, about one-half mile north of Fern Springs. The thickness of the outcrop is about ten feet. This clay has a tensile strength of about 70 pounds per square inch. It requires 22 per cent of water for plasticity and loses 5 per cent of its weight in burning. It has an air shrinkage of 8 per cent, the total shrinkage being 16 per cent. In the muffle at cone 17 it vitrifies and assumes a light pink color. It remains unchanged at cone 20. The slip glaze on the raw clay is good and the artificial glaze on the bisque is poor.

Another sample of this clay required 24 per cent of water for plasticity. It lost 5 per cent in burning and had a total shrinkage of 18 per cent. It burned white at cone 17, vitrifying and remaining unchanged at cone 20. The burned clay exhibits no cracks or crazes. Ten per cent of the clay was caught on 150 mesh screen. The rate of slaking is rapid. It vitrifies white to green. There is no absorption at cone 20 and above.

Davis & White Mill.—A white clay occurs in the public road near the Davis & White saw mill. On the opposite side of the draw from this outcrop there is an exposure of laminated clays containing two small seams of lignite. These clays are at a higher level than the white clay and since the former belongs to the Wilcox, it is more than probable that the latter also belongs to that formation. The crests of the ridges in this locality are occupied by a thick layer of Lafayette and Columbia.

The white clay has an average tensile strength of only 15 pounds per square inch. In water it slakes slowly to medium grain. The specific gravity is 2.42. The air shrinkage is only 2 per cent. The fire shrinkage is 3 per cent. The clay cracks and checks when burned at the same temperature and with the same rapidity of the average stoneware clay.

Loyd Church.—About two miles south of Webster, on the Macon road, there is an outcrop of white clay containing pink and purple tints. The outcrop is a few yards west of a church. The clay has a thickness of 12 feet. It underlies a bed of lignite and belongs to the Wilcox. The impressions of leaves have been found in the clay. The slopes, farther back from the draw, are occupied by Lafayette and Columbia. This clay was used for many years by the Loyd family in the manufacture of stoneware. It is a very plastic clay, having a specific gravity of from 2.41 to 2.61. In water it slakes slowly to fine grains. The average tensile strength of its air-dried brickettes is 77 pounds and the maximum is 88 pounds per square inch. The amount of water required to render the clay plastic is 25 per cent of its weight. The air shrinkage is 6 per cent. It vitrifies to a good, strong body at cone 5. It will take either the salt or slip glaze. It occupies about the same geological horizon as No. 68, which doubtless belongs to the Wilcox.

Bevill Hill.—This is a yellowish gray clay collected from an outcrop near the top of Bevill Hill, on the Octoc-Webster road. It belongs to the Porters' Creek sub-division of the Wilcox.

It is a sticky gumbo clay of fine texture. The clay contains a large per cent of silica, more than 50 per cent of which is uncombined and in a very finely divided state.

The average tensile strength of its air-dried brickettes is 179 pounds, while the maximum strength is 200 pounds per square inch.

The specific gravity is 2.40. The brickettes, in air-drying, shrink 10 per cent. This clay may be classed as a road-ballast clay.

Betheaton Church.—On the public road, near Betheaton Church, there is an outcrop of variegated clays, in which the prevailing tints are white, yellow and pink. This clay occurs at the base of the Lafayette.

The clay has a specific gravity of 2.40. The air shrinkage is 10 per cent. By mixing with an amount of sand sufficient to decrease the amount of shrinkage, this clay may be rendered suitable for earthenware and brick

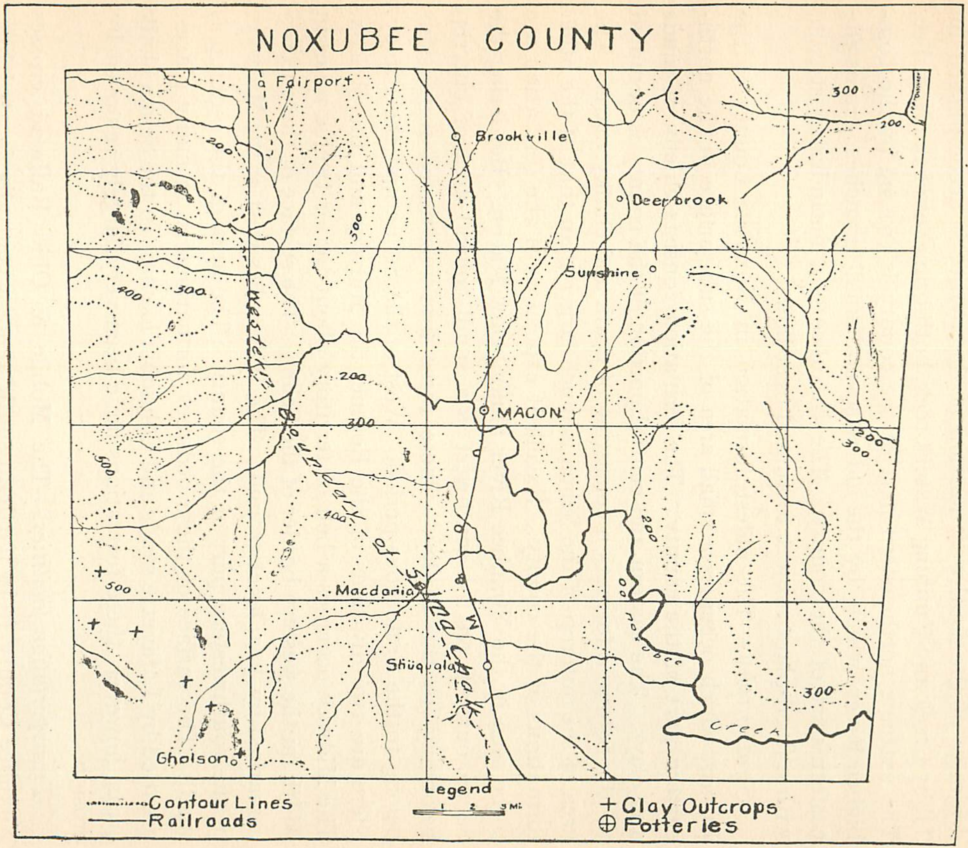
NOXUBEE COUNTY.

GEOLOGY.

Topography.—The eastern and central portions of Noxubee County are parts of a slightly rolling plain, which lies between 200 and 300 feet above sea level. Toward the west, the surface of the county rises with moderate abruptness to a higher plain, formed by the outcrop of the Wilcox formation. The highest recorded elevation in the county is at Brooksville, which is 269 feet above sea level. The minimum recorded elevation is at Macon, which is 194 feet above sea level. The surface of the Noxubee flood-plains below Macon, is somewhat lower than the latter elevation. The surface of the county reaches its maximum altitude in the southwestern portion of the county. The altitude is here, about 500 feet above sea level. This portion of the county exhibits also the greatest relief. For here the streams, near their heads, have cut deep into the soft rocks of the Wilcox and left a rugged topography.

Drainage.—The Noxubee River, which is a branch of the Tombigbee River, controls the greater part of the drainage of Noxubee County.

PLATE XXXV.



NOXUBEE COUNTY
Fairport
Brookville
Deerbrook
Sunshine
MACON
Macdonia
Shuqualak
Gholson
Western Boundary of Selma Chalk
Noxubee Creek
200
300
400
500
Legend
1 2 3 Mi.
Contour Lines
Railroads
+ Clay Outcrops
⊕ Potteries

The Noxubee River crosses the county in a general northwest by southeast direction. Toward the north the Noxubee has two principal western tributaries, Loakaformer Creek and Linn Creek. On the east there are also two branches, Coon Creek and West Water Creek. The drainage of the southwest portion of the county is accomplished by Tibby Creek and Running Water Creek, both branches of the Noxubee. The extreme northeastern part of the county is crossed by the Tombigbee River, which by the aid of several small branches, drains the eastern part of the county. The Noxubee is a meandering stream, with a flood-plain subject to annual over-flow.

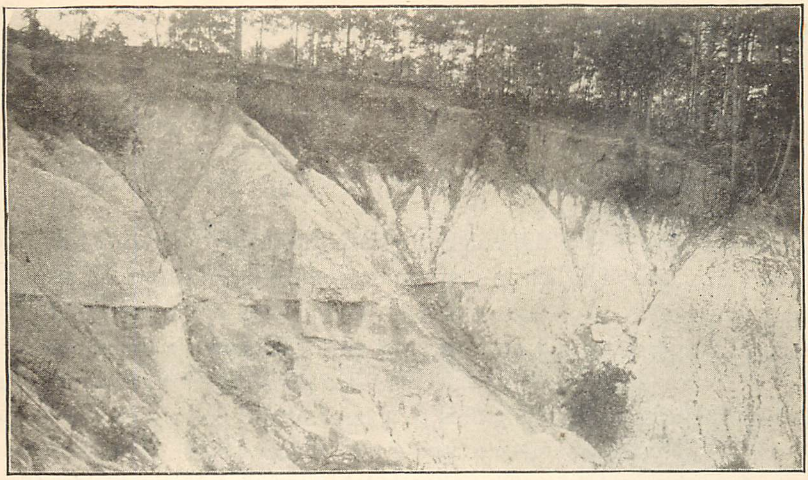
Stratigraphy.—The oldest formation in Noxubee County is the Eutaw, which occupies a small area of the sub-surface in the northeastern part of the county. The formation consists chiefly of sands and clays. The eastern and central portion of the county is occupied by the Selma, a formation consisting of chalk and chalky marls. The area of the outcrop of the Selma is much larger than that of the other formations of the county. Excellent exposures of the formation are to be seen in the Noxubee River bluffs below Macon. Bordering the Selma outcrop on the southwest is a small conical area of outcrop belonging to the Ripley. These three first mentioned formations belong to the Cretaceous period. West of the Selma and the Ripley, there are two divisions of the Eocene, the Midway and the Wilcox. The Midway occupies a belt of territory about ten or twelve miles in width on the western border of the Selma. The surface of the outcrop is marked by low, level ground. The Wilcox lies west of the Midway, in the southwestern part of the county. The area of the outcrop is small. The surface of these bed-rock formations is, in many places, mantled by Lafayette sands and Columbia loams. In the Selma chalk areas, however, these formations have been very largely removed by erosion.

Transportation facilities.—The Mobile & Ohio Railroad crosses Noxubee County from north to south along a centrally located line. The shortest line from this road to the clay bearing district herein described, is about fifteen miles.

CLAYS AND CLAY INDUSTRY.

Gholson.—An outcrop of white Wilcox clay occurs on the farm of Mrs. Laura Haynes, at Gholson. The outcrop of the clay is in a gulch,

PLATE XXXVI.



A. AN OUTCROP OF WHITE WILCOX CLAY NEAR GHOLSON, NOXUBEE COUNTY.

B. A NEARER VIEW OF A PART OF THE SAME OUTCROP.

about one-fourth of a mile east of Gholson, near the public road. On one side of the gulch the following section is exposed:

Section of Haynes Farm at Gholson.

5. Red sand.......................................10.0 feet.
4. White clay.....................................15.0 feet.
3. Limonite....................................... .3 feet.
2. Yellow clay....................................15.0 feet.
1. Variegated sand................................20.0 feet.

On the east side of the gulch the variegated sand contains lens-like masses of clay. The white clay has a tensile strength of 58 pounds per square inch. Its loss of weight in burning is 3.5 per cent. It requires 24 per cent of water for plasticity. Has an air shrinkage of 8 per cent, fire shrinkage 8 per cent, total shrinkage 16 per cent. In the muffle at cone 20 it vitrifies to a light cream color. In the flame at cone 17 it vitrifies and assumed a bluish gray color. The slip glaze is good on the raw clay. The rate of slaking of the clay is rapid. Clay undergoes the following changes during firing:

TABLE 64.

CHANGES OF GHOLSON CLAY IN BURNING.

Clay cone:						
Pyrometric cone	01	3	4	8	13	20
Color	pink	pink	pink	light gray	dark gray	light gray
Hardness	soft	soft	soft	hard	steel hard	steel hard
Shrinkage	......	......	......	2	5	5
Absorption	16	15	13	10	....	....

Less than 1 per cent of the clay could not be washed through a screen of 150 mesh.

Butler farm.—There are several exposures of White Wilcox clays on the W. B. Butler farm, three miles south of Hashuqua. The outcrops occur in the spurs of a small creek. At one point the following section is exposed:

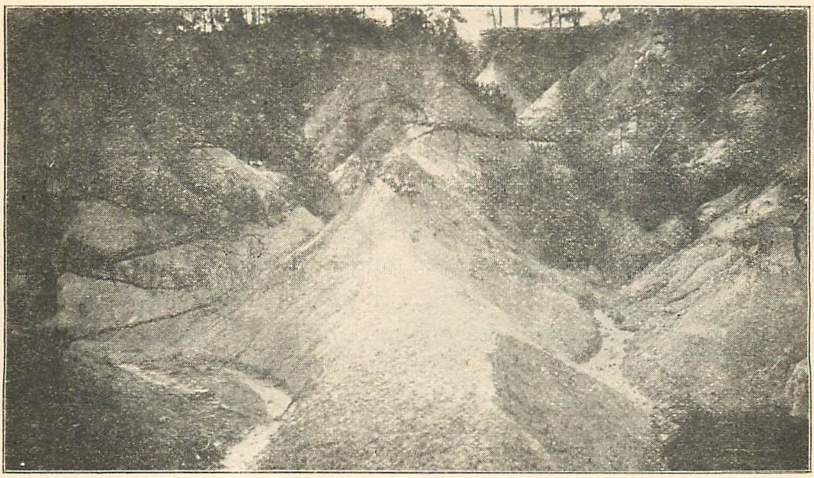
Section on Butler Farm.

3. Sand, yellow and red...........................20 feet.
2. White plastic clay.............................15 feet.
1. Yellow and white sand..........................20 feet.

There are several outcrops of these clays and the clay bed occurs about the same horizon in each case. The white clay slakes rapidly when placed in water and requires 25 per cent of water for plasticity.

PLATE XXXVII.

A. SHOWING AN OUTCROP OF WHITE WILCOX CLAY ON W. B. BUTLER'S FARM NEAR HASHUQUA, NOXUBEE COUNTY.



B. SHOWING EROSION IN THE CLAY OF THE ABOVE OUTCROP.

The clay has an air shrinkage of 8 per cent, fire shrinkage, 4 per cent, total shrinkage, 12 per cent. Loss of weight in burning, 7 per cent. The slip and artificial glaze are both good on the raw clays. At cone 17 in the muffle, the clay vitrified and formed a white body. No change took place at cone 20. The tensile strength of the raw clay is 41 pounds per square inch. The following table shows the changes which take place during firing:

TABLE 65.

CHANGES OF BUTLER CLAY IN BURNING.

Clay cone:				
Pyrometric cone	01	8	13	20
Color	white	white	bluish white	white
Hardness	soft	hard	steel hard	steel hard
Shrinkage	....	5	10	10
Absorption	16	14	....	....

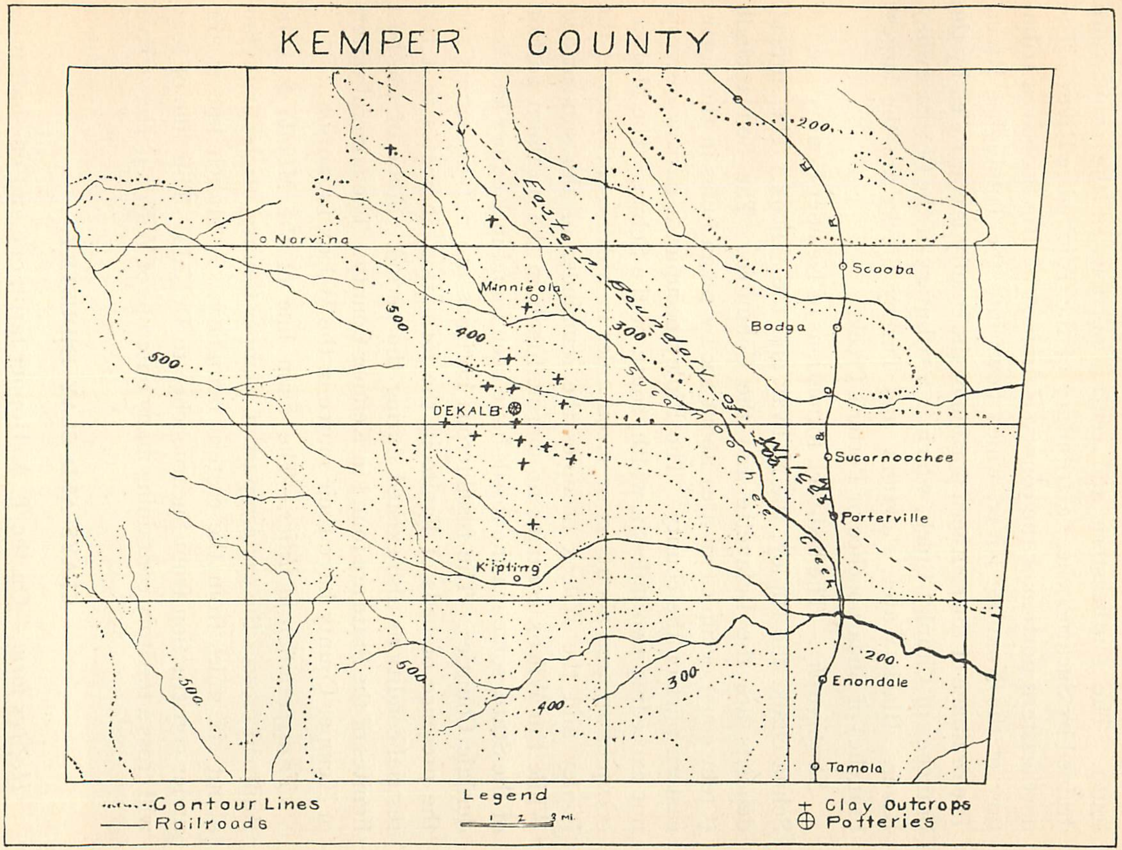
All of the clay passed through a screen of 150 mesh.

Other localities.—White plastic clay occurs on the W. J. Sanders farm, the L. A. Cotton, on the W. J. Reed farm, all south of Hashuqua factory, and in a gulch one-half mile west of the factory.

KEMPER COUNTY.

GEOLOGY.

Topography.—The western portion of Kemper County is occupied by a relatively high plain, which has an elevation of between 400 and 500 feet above sea level. The surface of this plain descends eastward to a lower plain which has an elevation of about 200 feet above sea level. The lower plain called the Flatwoods, is a comparatively level area, having a width of six or seven miles. The descent from the higher plain is somewhat abrupt as a rule. In the northeastern portion of the county, there is a small area of prairie, which is gently rolling and slightly more elevated than the Flatwoods. The most rugged types of relief are found in the eastern border of the higher plain, where the streams have cut deep y into its margin. The lowest recorded elevation in the county is 192 feet above sea level and this altitude is not far from the actual minimum. The maximum elevation is in the northwestern part of the county but has not yet been recorded, though it is in the neighborhood of 500 feet.


KEMPER COUNTY
Norvina
Minnieola
DEKALB
Kipling
Scooba
Bodga
Sucarnoochee
Porterville
Enondale
Tamola
Eastern Boundary of Wilcox
Sucarnoochee Creek
R. R.
200
300
400
500
Legend
Contour Lines
Railroads
1 2 3 mi.
Clay Outcrops
Potteries

Drainage.—Two large streams assist in the drainage of Kemper County, the Tombigbee River on the east and the Chickasawhay on the south. The southeastern and central portions of the county are drained by Sucarnoochee, a tributary of the Tombigbee River. The northeastern portion of the county is drained by Big Scooba, a tributary of the Noxubee River, which flows into the Tombigbee River. The drainage of the southern portion of the county is controlled by the branches of Chunky Creek, which is a tributary of the Chickasawhay River. Black Water, Pawtigfa, and Turkey Creeks are the largest branches of Sucarnoochee or Porter's Creek.

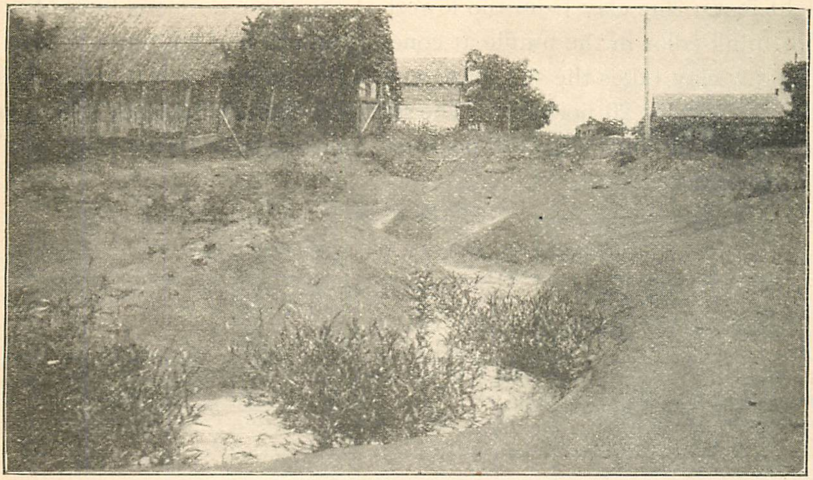
Stratigraphy.—The bed-rock formations of Kemper County are the Selma chalk, the Ripley, the Midway and the Wilcox. The surficial deposits are the Lafayette and the Columbia. The Selma chalk (Cretaceous) occupies an area about six by seven miles in the northeastern part of the county. The Ripley occupies a narrow outcrop, not exceeding two miles in width, south of the Selma. The Midway occupies an area about six or seven miles in width, southwest of the Ripley and the Wilcox occupies the remainder of the sub-surface. While the Wilcox contains no marine fossils in the northern portion of the State, some marine fossils have been found in Kemper and Lauderdale Counties. The fossiliferous horizons are not numerous and the presence of beds of lignite in the formation, indicates that terrestrial conditions also existed during the period. Some of the best lignites of the State are found in Kemper County. The mineral waters of Kemper County have their source in the Wilcox formation.

Transportation facilities.—The main line of the Mobile & Ohio Railroad crosses the eastern part of Kemper County, traversing a line about six miles from the eastern boundary. A branch line is also under construction from Sucarnoochee to DeKalb. This line of road will cross a territory containing many outcrops of Wilcox pottery clays.

CLAYS AND CLAY INDUSTRY.

Hopper farm.—On the T. A. Hopper farm, one and one-half miles north of DeKalb, there is a cream colored plastic clay. The clay occupies three horizons on a slope which is crossed by the public road, as it descends toward Sucarnoochee Creek. The ridge in which the clay occurs is composed of alternate layers of clay and sand. Near the base

PLATE XXXIX.



A. SHOWING EROSION IN THE RED SANDS OF THE LAFAYETTE AT DEKALB.

B. SHOWING EROSION IN THE IRONSTONE LAYERS BENEATH THE RED SANDS AT DEKALB.

of the ridge there is a bed of lignite, which has a thickness of about eight feet. The clay from the lowest of the three horizons burns to a light pink color in the muffle at cones 17 and 20 and without cracking. The raw clay takes the slip glaze well. The amount of water required for plasticity is 26 per cent. The loss of weight in burning is 8½ per cent. The air shrinkage is 8 per cent, fire shrinkage 16 per cent, total 24 per cent.

TABLE 66.

CHANGES IN HOPPER CLAY IN BURNING.

Clay cone:						
Pyrometric cone	01	2	4	8	13	20
Color	light pink	pink	pink	white	dark gray	light gray
Hardness	soft	soft	soft	med. hard	steel hard	steel hard
Shrinkage	....	......	......	1	5	5
Absorption	22	19	20	15	....	....

Less than 1 per cent of the clay was caught on a screen of 150 mesh. The rate of slaking is rapid.

A sample of clay from the middle layer burns to a bluish white color and vitrifies in the flame at cone 17. It remains unchanged at cone 20. The amount of water required for plasticity is 27 per cent. The air shrinkage is 8 per cent, fire shrinkage 10 per cent, total shrinkage 18 per cent. The rate of slaking is rapid.

A sample of clay from the upper bed vitrifies and turns iron gray at cone 13 in the flame. At cone 17 in the flame it exhibits fused spots, iron brown in color. The clay vitrified without cracking. The amount of water required for plasticity is 28 per cent.

Moscow Road.—In the public road, one mile south of DeKalb, the following section is exposed:

3. Red to mottled sand .... 10 to 25 feet.
2. White clay .... 6 feet.
1. Sand, orange colored .... 25 feet.

The layer of white clay thins out at one point to a thickness of about one foot. In the opposite direction it seems to increase in thickness.

The amount of water required for plasticity is 18 per cent. The loss of weight in burning is 5 per cent. The air shrinkage is 6 per cent, fire shrinkage 2 per cent, total shrinkage 8 per cent. In the muffle at cone 17 the clay vitrifies and changes to a light pink color. The body of the burned clay in compact and has no cracks. No change takes place in the clay at the temperature of cone 20. This clay takes the slip and artificial glaze on both the bisque and the raw clays. The tensile strength of the clay is 45 pounds per square inch. Its rate of slaking is rapid.

TABLE 67.

CHANGES OF MOSCOW ROAD CLAY IN BURNING.

Clay cone:					
Pyrometric cone	01	2	3	19	20
Color	white	pink	white	dark gray	white
Hardness	soft	soft	soft	steel hard	steel hard
Shrinkage	....	1	2	5	5
Absorption	18	20	20	5	....

The air shrinkage is 8 per cent, fire shrinkage 10 per cent, total shrinkage 18 per cent. Rate of slaking very rapid.

Waddel farm.—In the public road adjoining the A. A. Waddel farm, three miles south of DeKalb, there is an outcrop of white plastic clay. The clay forms a part of the following section:

3. Red sand.................................15 to 20 feet.
2. White potter's clay........................ 5 to 6 feet.
1. Yellow sand with ironstone......................20 feet.

The ridge in which this section is exposed extends for a mile or more to the west and forms a considerable area on the Waddel farm. The overburden of sand seems to increase in thickness westward. The white clay requires 21 per cent of water for plasticity and shows a loss of 6 per cent in weight in burning. It has an air shrinkage of 6 per cent, its fire shrinkage is 2 per cent. The total shrinkage is 8 per cent. In the flame at cone 13 it burns to a light gray to cream color and vitrifies without cracking. The slip glaze and the artificial glaze are good on both the raw clay and the bisque. The clay was vitrified, white, and showed no absorption at cone 20.

Hull farm.—A white clay occurs on the John Hull place, about one and a half miles southeast of DeKalb, on the Moscow road. The clay bed has an overburden of red sand.

In the muffle at cone 17 the burned clay was cream colored and vitrified. In the flame at cone 20 the clay was unfused but bluish-white in color. The water required to render it plastic is 15 per cent of

PLATE XL.

A. SHOWING TYPICAL EROSION IN WILCOX CLAYS NEAR DEKALB, KEMPER CO.

B. NEAR VIEW OF A PORTION OF THE ABOVE OUTCROP.

its weight. The loss of weight in burning is 7 per cent. The clay slakes rapidly. When applied to the raw clay or to the bisque the natural and artificial glazes are good. The burned clay exhibits no absorption at cone 20. This clay is a good ball clay.

Golliher's farm.—On the P. L. Golliher farm, south of DeKalb, the following section is exposed in the pasture west of the dwelling a few rods:

3. Red sand (Lafayette overburden)	3 to 5 feet.
2. White plastic clay	5 to 6 feet.
1. Yellow and white sand with ironstone	15 feet.

The length of the outcrop is about three rods. A sample of the clay exhibited the following physical properties: It slakes rapidly in water and requires 20 per cent of water for plasticity. The air shrinkage is 12 per cent and the total shrinkage at cone 20 is 16 per cent. At cone 20 in the flame the burned clay is grayish white and in the muffle white and vitrified, exhibiting no absorption. The clay will take a glaze and can be used for stoneware.

Pool's Mill.—At the mill of W. H. Pool, about four miles southeast of DeKalb, on the Marion road, the following section is exposed:

5. Clay, white, plastic	3 to 4 feet.
4. Sand	10 feet.
3. Yellow, mottled plastic clay	6 to 8 feet.
2. Lignite	3 to 4 feet.
1. Blue plastic clay	5 feet.

Public road.—In the public road, about three-fourths of a mile south of Dekalb, there is an outcrop of white clay with bluish and pink spots in it. The amount of water required for plasticity is 22 per cent. The loss of weight in burning is 23 per cent. The air shrinkage is 6 per cent, fire shrinkage 2 per cent, total shrinkage 8 per cent. In the muffle at cone 17 it vitrified and turned gray. In the flame it cracked and warped. The rate of slaking is rapid.

Stovall farm.—On the Stovall farm, in a crenulated gulch, which has vertical walls of about thirty feet in height, there is an outcrop of laminated clay, composed of alternate white and yellow layers. A sample of the yellow clay burned to a dark red body in the muffle at cone 17. The total shrinkage at that temperature is 33 per cent. In the flame at cone 13 the clay was straw colored and vitrified. The water required for plasticity is 30 per cent. A sample of the white clay vitrified in the muffle and was unfused at cone 20. Its total shrinkage was 16 per cent and color white at that temperature. In the flame the color was dark brown, it was vitrified and exhibited no absorption at that temperature.

Snooty Creek.—Outcrops of white plastic clays occur on both sides of Snooty Creek south of DeKalb.

Marion road.—White clays outcrop on the Marion road about two and one-half miles from DeKalb, on the J. W. Wall's farm and also on the S. F. Wall's farm.

Livingston road.—An outcrop of white clay occurs on the Livingston road, about one mile east of DeKalb, and again about three and one-half miles and five miles east.

Kellis road.—White clay occurs on the Kellis road one and one-half, one and three-fourths, four and one-half miles and five miles north of DeKalb, on Lon Wilson's farm, near Wilson school house.

Minnieola.—Near Minnieola store, a few rods east, there is an outcrop of white plastic clay. Also one and one-half miles north of Minnieola. There are two layers of white clay in red sand with ironstone above.

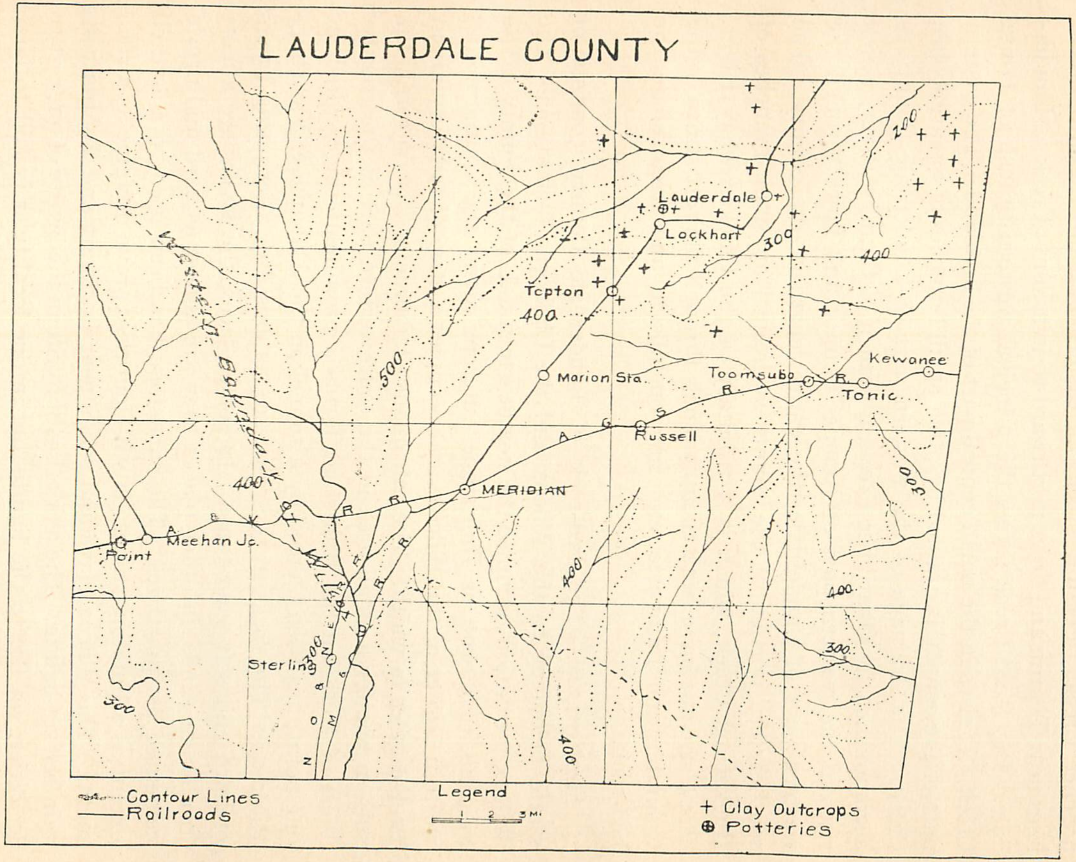
Kellis store.—White clay occurs at the following points near Kellis: Two and one-half miles south, near public road, north of DeKalb one-half mile and one mile north.

LAUDERDALE COUNTY.

GEOLOGY.

Topography.—The relief of Lauderdale County is moderately rugged. The greater part of the surface of the county is occupied by a highland which has an extreme elevation of about 500 feet above sea level. The highland is cut into from the north by the branches of the Tombigbee River and on the south and southwest by tributaries of the Pascagoula River system. Near the heads of these tributaries steep walled gulches and ravines are common, but the middle and lower courses of the streams are generally marked by relatively broad level valleys. The lowest recorded elevation in the county is 208 feet at Lauderdale and the maximum recorded elevation is 358 feet at Marion.

PLATE XLI.

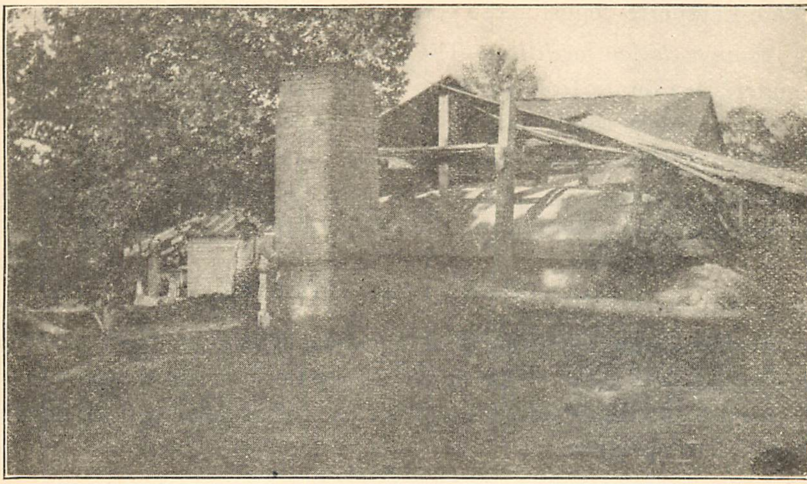

LAUDERDALE COUNTY
Lauderdale
Lockhart
Tepton
Marion Sta.
Toomsuba
Kewanee
Tonic
Russell
MERIDIAN
Meehan Jc.
Point
Sterling
Western Boundary of Wilcox
200
300
400
500
Legend
Contour Lines
Railroads
1 2 3 MI.
+ Clay Outcrops
⊕ Potteries

Drainage.—The drainage of the northeastern part of Lauderdale County is accomplished by Ponta Creek which is a branch of Sucarnoochee Creek. Possum Creek, an eastern branch of Ponta Creek, rises near Topton and flows northward to join Ponta Creek at Lauderdale. Big Reed Creek forms the principal western branch of Ponta Creek. It rises in the north central part of the highland. The eastern part of the county is drained by other small branches of Sucarnoochee Creek. The drainage of the western part of Lauderdale County is accomplished by Okatibbee Creek, a branch of Chunky River, which rises in the western part of Kemper County and flows through the western part of Lauderdale, the entire length of the county. The southeastern portion of the county is drained by small branches of Buckatuna Creek, which is a tributary of the Chickasawhay River. These streams have sunk their channels through the soft strata of the Columbia and Lafayette, exposing on hillside and streamslope the bed-rock.

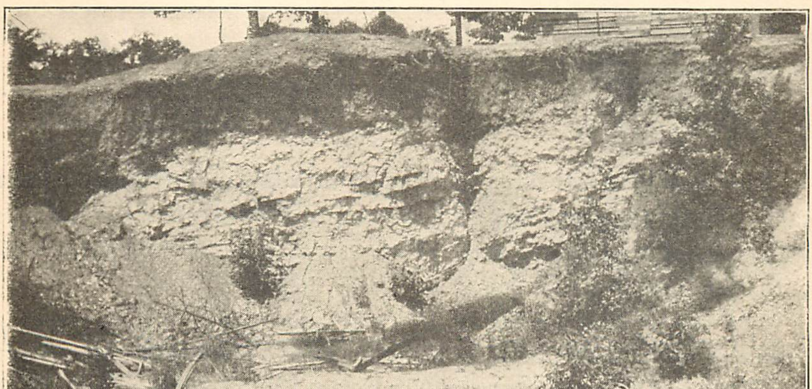
Stratigraphy.—The bed-rock of Lauderdale County consists of strata belonging to the Wilcox and the Claiborne formations. The Wilcox formation occupies the northeastern half of the county. The Silicious Claiborne or Buhrstone outcrops along the southern and western border of the Wilcox, and occupies a strip of territory about twelve miles in width. The calcareous Claiborne or Lisbon forms the sub-surface for a small area in the southwestern part of the county. West of Meridian the Buhrstone forms a prominent ridge, which at one point, has been pierced by a tunnel on the Alabama & Vicksburg Railroad. The rocks in the ridge are composed of alternating layers of hard and soft sandstones. In some places, the layers are almost incoherent sands, in other places they are almost as hard and firmly cemented as quartzites. The sandstone has been used to a limited extent as a building stone. It will doubtless prove of value as a road metal. The Wilcox clays and sands near Lockhart and Topton contain beds of lignite. The oxidation of pyrite in the lignite of one or two localities, set fire to the lignite and in one locality it is said to have burned for fifteen years.

The surface formations of Lauderdale County consist of sand, gravels, clays and ironstones of Lafayette age and yellow sandy loams of Columbia age. The high ridges south and southeast of Meridian

PLATE XLII.



A. VIEW OF KILN OF POTTERY ONE MILE NORTH OF LOCKHART.



B. VIEW OF THE CLAY PIT OF THE ABOVE POTTERY SHOWING STRATIFICATION.

are capped with red sands and clays belonging to the Lafayette. These Lafayette deposits also contain ironstone of varying purity.

Transportation facilities.—The Mobile & Ohio Railroad crosses Lauderdale County from north to south. The New Orleans & Northeastern parallels the Mobile & Ohio as far north as Meridian and the Alabama & Great Southern crosses the county from Meridian to the east line. Pottery clays are located near the Mobile & Ohio and the Alabama & Great Southern in the northern part of the county.

CLAYS AND CLAY INDUSTRY.

Lockhart.—In the vicinity of Lockhart there are many outcrops of white Wilcox clays. One mile north of Lockhart in a railroad cut, there is an outcrop of gray micaceous clay. This clay has the following chemical composition:

TABLE 68.

ANALYSIS OF LOCKHART CLAY.

Moisture (H_2O)	3.14
Volatile matter (CO_2, etc.)	7.20
Silicon dioxide (SiO_2)	58.05
Aluminum oxide (Al_2O_3)	27.79
Ferric oxide (Fe_2O_3)	1.05
Calcium oxide (CaO)	2.00
Magnesium oxide (MgO)	.25
Total	99.48

RATIONAL ANALYSIS.

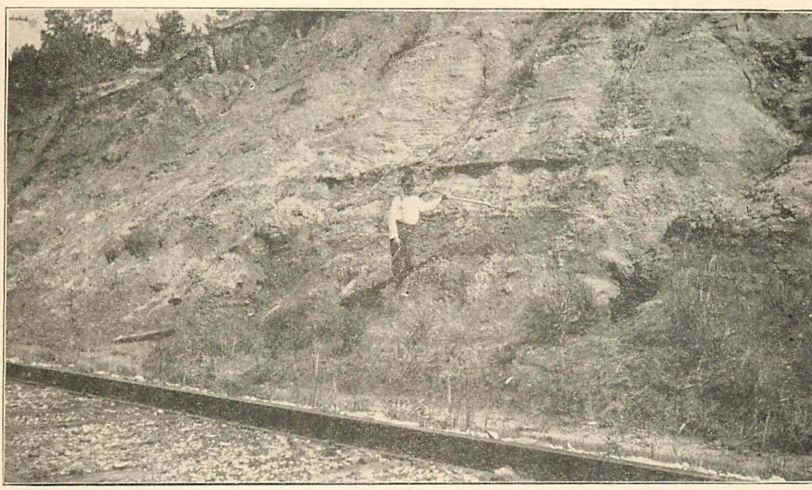
Clay substance	70.42
Free silica	15.42
Fluxing impurities	3.30

The clay is stratified, occurring in thin layers interstratified with sand. Both the sand and the clay contain small particles of mica, which are of microscopic size. The color of the clay is grayish white with yellowish iron streaks.

The physical properties of this clay are as follows: The average tensile strength is 98 pounds per square inch. The maximum strength exhibited is 112 pounds per square inch. The specific gravity of the clay is 2.44. The air shrinkage is 4 per cent, fire shrinkage 11 per cent, total shrinkage 15 per cent. The amount of water required for plasticity is 23 per cent. In the flame at cone 17 it burned to a dark gray color and vitrified without cracking. At cone 20 it remained unchanged. The raw clay takes both the slip and artificial glaze well.

Plate XLIII.

A. VIEW OF LIGNITE LAYER IN WILCOX FORMATION THREE MILES NORTH OF LOCKHART. SPADE POINT RESTS AT BOTTOM OF LAYER, CAP ROCK PROJECTING ABOVE.



B. VIEW OF LIGNITE LAYER IN OPPOSITE SIDE OF THE SAME CUT. SPADE AT BOTTOM.

TABLE 69.

CHANGES OF WEDGEWOOD CLAY IN BURNING.

Clay cone:						
Pyrometric cone	01	3	4	8	13	20
Color	white	light pink	pink	light gray	dark gray	white
Hardness	soft	soft	soft	hard	steel hard	steel hard
Shrinkage	....	....	......	10	15	15
Absorption	20	15	15	10	.03	....

Uses.—The clay from this outcrop has been used in the manufacture of stoneware for a number of years. For a time it was shipped to Meridian and used there in the manufacture of stoneware. It was also used in a limited way in the manufacture of brick. A Mr. Vestal established a pottery for the manufacture of stoneware at this point about forty years ago. The pottery, which was a crude hand pottery, was afterwards bought and operated by the Wedgewood Brothers, who changed it into a steam power pottery. The pottery is now owned by William Wedgewood It was not operated during the past year. The clay has been used with success in the manufacture of ornamental terra cotta, tombstones, stoneware and decorated ware.

Brown farm.—On the B. R Brown farm, about one-half mile north of Lockhart, there is an outcrop of plastic clay. The clay is light brown in color and contains microscopic grains of mica and small iron concretions. In its physical properties this clay exhibits an average tensile strength of 78 pounds per square inch. About 2 per cent of the clay was retained on the screen of 150 mesh. The clay slakes rapidly and has a specific gravity of 2.38. It requires 30 per cent of water for plasticity.

TABLE 70.

CHANGES OF BROWN CLAY IN BURNING.

Clay cone:		
Pyrometric cone	01	19
Color	pink	yellowish gray
Hardness	soft	steel hard
Shrinkage	....	5
Absorption	17	06

The chemical properties of the clay are exhibited in the following table:

TABLE 71.

ANALYSIS OF BROWN CLAY.

Moisture (H_2O)	4.29
Volatile matter (CO_2, etc.)	7.74
Silicon dioxide (SiO_2)	58.21
Aluminum oxide (Al_2O_3)	27.23
Ferric oxide (Fe_2O_3)	.83
Calcium oxide (CaO)	.65
Magnesium oxide (MgO)	.41
Total	99.36

RATIONAL ANALYSIS.

Clay substance	69.00
Free silica	16 44
Fluxing impurities	1.89

Eakin farm.—An outcrop of Wilcox white clay is located on the E. A. Eakin farm seven miles east of Lauderdale. The clay is a white clay presenting blue and pink surfaces along joint planes. There are two outcrops of the clay and the bed probably underlies 100 acres of land. The thickness of the bed in the northern outcrop is about nine feet. In the southern outcrop it is about eighteen feet. In the muffle at cone 17 the clay burns to a light cream color or white. At cone 20 no change takes place. The clay vitrifies at cone 13. It takes the slip glaze on the raw clay. The amount of water required for plasticity is 26 per cent. The loss of weight in burning is 4 per cent. The air shrinkage is 8 per cent, fire shrinkage 8 per cent, total shrinkage 16 per cent. Its rate of slaking is rapid.

TABLE 72.

CHANGES OF EAKIN CLAY IN BURNING.

Clay cone:					
Pyrometric cone	01	2	7	19	20
Color	white	pink	light yellow	bluish gray	gray
Hardness	soft	soft	hard	steel hard	steel hard
Shrinkage	....	....	2	8	8
Absorption	18	21	18	12	....

The Eakin clay was at one time used in Meridan in the manufacture of stoneware. The clay was shipped by a railroad running from York, Alabama, to Lauderdale, Mississippi. The railroad was taken up a

PLATE XLIV.

A. SHOWING METHOD OF CULTIVATING THE SLOPES IN WILCOX AREA, LAUDERDALE COUNTY.

B. AN OUTCROP OF WHITE WILCOX CLAY ON THE EAKIN FARM, LAUDERDALE COUNTY.

number of years ago. The clay has been hauled to Cuba, Alabama, for a great many years and used in the manufacture of stoneware. It is used just as it is taken from the pit.

Clara Rushing.—On the Clara Rushing farm, near Topton, there is an outcrop of grayish potter's clay which has an overburden of lignite. The lignite has a thickness of about ten feet. At one time it caught fire by the oxidation of iron pyrites contained in it, and is said to have burned ten years. The underlying clay is a gray plastic clay with a joint structure. It requires 27 per cent of water for plasticity. The loss of weight in burning is 2 per cent. It has an air shrinkage of 8 per cent and a fire shrinkage of 7 per cent, total shrinkage being 15 per cent. Its rate of slaking is slow. In the flame at cone 17 it burns to a dark gray body which exhibits incipient viscosity. At cone 20 in the muffle it vitrifies without cracking. It takes the slip glaze on raw clay poorly. At a higher temperature than cone 20 in the flame it shows complete viscosity.

King farm.—On the Jno L. King farm, about one and one-half miles north of Lockhart, the following section is exposed on a hillside:

Section on King Farm.

6. Red sandy clay	10 feet.
5. Lignite	4 feet.
4. Clay	20 feet.
3. Dark earth	4 feet.
2. Lignite	4 feet.
1. Clay	3 feet.

The dark earth contains iron pyrites and soluble salts, produced by the decomposition of the iron pyrites. The clays are gray in color and plastic.

Topton—At Topton a white plastic clay was found on the John Hughes farm. An outcrop occurs in a small gully in the side of the public road. The clay requires 26 per cent of water for plasticity. It has an air shrinkage of 8 per cent, fire shrinkage 7 per cent, total shrinkage 15 per cent. It loses 3 per cent of its weight during firing. It exhibits incipient viscosity in the flame at cone 20 and vitrifies to a dark gray body in the muffle at cone 17. It exhibits no cracks at this temperature. Its rate of slaking is rapid.

Geo. Lucky farm.—On the Geo. Lucky farm there is an outcrop of gray clay which has a thickness of five feet in the exposure. The clay

PLATE XLV.

A. WATER FALLING OVER LAMINATED WILCOX CLAY NEAR TOPTON, LAUDERDALE COUNTY.

B. WHITE WILCOX CLAY NEAR PUBLIC ROAD ON LACKEY FARM, TOPTON.

has an overburden of red sand in which there are remains of a petrified tree. The overlying sands belong to the Lafayette and the clay belongs to the Wilcox.

The physical properties of the clay are as follows: It requires 27 per cent of water for plasticity, has an air shrinkage of 12 per cent, fire shrinkage of 4 per cent, total shrinkage is 16 per cent. The loss of weight during firing is 5 per cent. In the flame at cone 20 it vitrifies to a steel blue body. At higher temperatures it is dark gray, exhibits no absorption and also vitrifies.

E. P. Brown farm.—On the E. P. Brown farm, one mile south of Lockhart, there is a gray plastic clay outcropping in the public road. The clay in the exposure which is on the side of a hill, has a thickness of more than ten feet. The clay is interstratified with sand and has an overburden of sand and sandy clay. This clay is completely fused at cone 9 or perhaps a little less. The amount of water required for plasticity is 31 per cent. It has an air shrinkage of 12 per cent. When burned the clay swells at the point of incipient fusion. The loss of weight in burning is 3 per cent. At cone 6 the clay is vitrified and has a dark brown color. It will not take the slip glaze. The clay was completely fused at less than cone 20.

Other localities.—The white plastic Wilcox clays are found also, in the following localities: At several points along the public road between Lockhart and Topton. On the Joe Gunn farm, near Topton. At several points on the public road, between Lockhart and Lauderdale. On the W. Mathena farm, two miles north of Lauderdale. On the J. E. Bailey farm, one mile northeast of the E. A. Eakin farm. On the J. P. Payne farm, east of Eakins. On the N. S. Shelby farm, north of Eakins. On the G. B. Simmons farm, west of Eakins.

CLAYS NOT INCLUDED IN THE TUSCALOOSA AND WILCOX FORMATIONS.

The analyses given in the following table are of clays which belong to formations occurring principally in the southern part of the State. Clay No. 1, of the table, is used by Mr. Geo. E. Orr, in his pottery at Biloxi, in Harrison County. The clay is obtained near Biloxi. Mr. Orr uses the clay in the manufacture of art pottery. The ware is made very thin and presents a variety of forms. Both glazed and unglazed articles are manufactured. The temperature at which the ware is burned is usually low. Some articles are decorated in many colors and the thin walled articles are often twisted or crinkled into odd shapes.

Clay No. 2 is from the Weatherby farm, north of Taylorsville, Smith County. It is a white clay from the Lafayette probably, though it may belong to the Grand Gulf. It has been used locally in the manufacture of fire brick.

Clay No. 3 is from the gravel pit near Morton, Scott County. The clay is white in color and contains a high percentage of kaolinite.

Clay No. 4 is a white plastic clay from Stonington, Jefferson County. It belongs to the Grand Gulf formation and has been used in the manufacture of white face brick.

Clay No. 5 is a grayish white clay from a locality about five miles south of Vicksburg, in Warren County.

TABLE 73.

ANALYSES OF CLAYS FROM OTHER AREAS.

	No. 1	*No.* 2	*No.* 3	*No.* 4	*No.* 5
Moisture (H_2O)	1.48	1.28	1.09	1.24	3.19
Volatile matter (CO_2, etc.)	5.83	6.60	8.72	4.08	8.26
Silicon dioxide (SiO_2)	73.40	71.29	60.20	78.17	58.50
Aluminum oxide (Al_2O_3)	17.24	16.78	36.72	13.23	19.04
Ferric oxide (Fe_2O_3)	1.30	3.30	3.17	1.73	1.93
Calcium oxide (CaO)	.32	.14	.89	.28	1.48
Magnesium oxide (MgO)	.41	.41	1.83	.56	1.66
Sulphur trioxide (SO_3)		Trace	Trace	Trace	Trace
Totals	99.98	99.80	112.62	99.29	94.06

RATIONAL ANALYSES.

Clay substance	43.69	42.52	93.39	33.53	29.50
Free silica	46.95	45.55	3.63	57.87	59.11
Fluxing impurities	2.03	3.85	1.39	2.57	6.99

ACKNOWLEDGMENTS.

The writer desires to express his appreciation of the many courtesies extended to him by the manufacturers of pottery products in Mississippi, Ohio, Pennsylvania and New Jersey. He is further indebted to the works of Bourry, Orton, Ries, Bleininger, Beyer, Williams and other writers on ceramic subjects. The information obtained from these sources has been of great importance in the preparation of this report.

The greater part of the chemical work, included in the report, has been done under the direction of Dr. W. F. Hand, State Chemist, and to him and his corps of assistants full credit is due. A few analyses derived from other sources are credited at other places in the report.

To all those citizens of the State, who have assisted me in any way in my work in the field, I take this means of expressing my appreciation of their valued services.

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