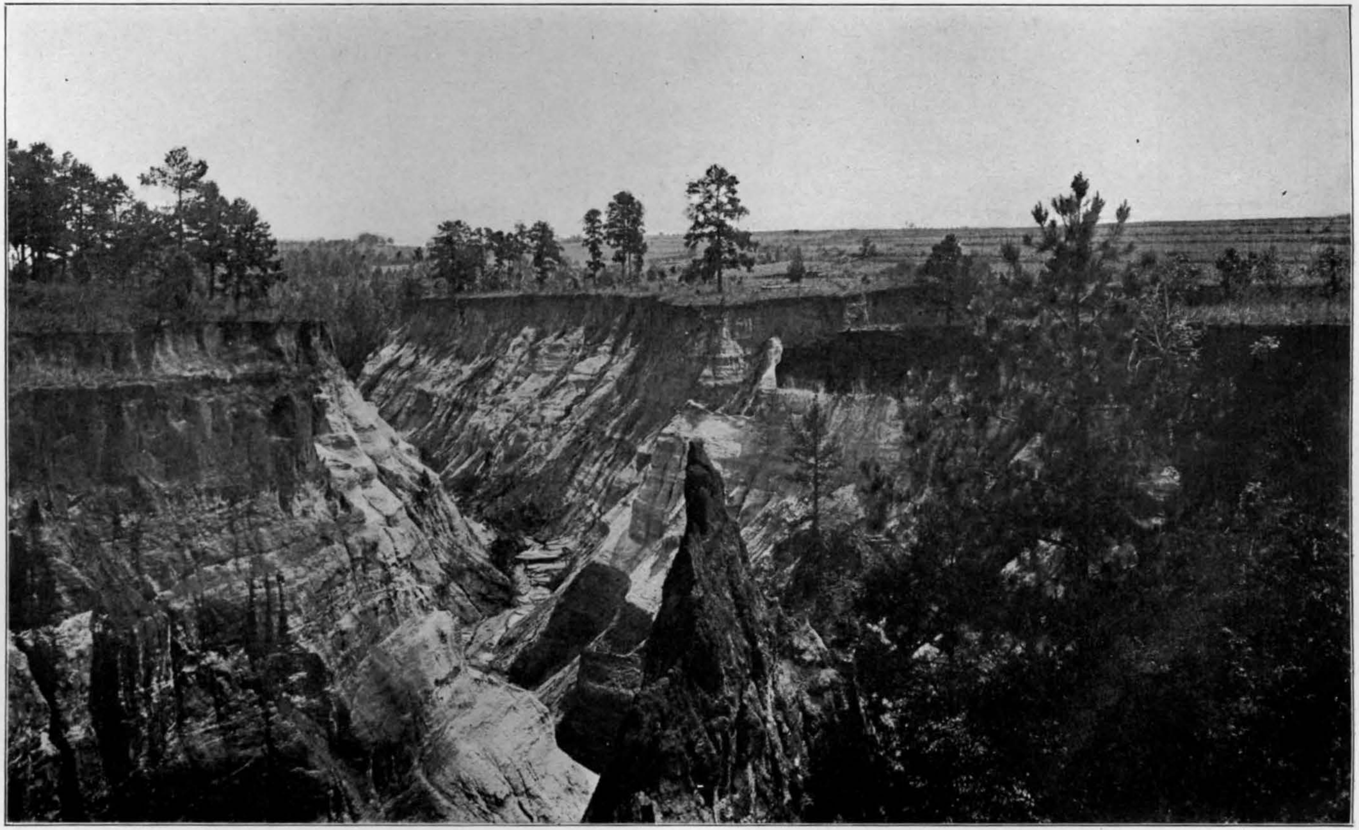

EROSION GULLIES IN UPPER CRETACEOUS SANDS, EIGHT MILES WEST OF LUMPKIN, STEWART COUNTY, GEORGIA

GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN No. 18

SECOND REPORT

ON THE

CLAY DEPOSITS

OF

GEORGIA

BY

OTTO VEATCH
Assistant State Geologist

Chas. P. Byrd, State Printer, Atlanta.
1909

ERRATA

1. On page 62, 28th line, for "212," read *100*.
2. On page 73, the foot-note should be transposed to page 74.
3. On page 74, 29th line, for "fossile," read *fossils*.
4. On page 74, 29th line, figure "1," should read *2*.
5. On page 74, foot-note "1" should be numbered *2*.
6. On page 85, 11th line, for "gypsums," read *gypsum*.
7. On page 86, 24th and 25th lines, for "doubtless," read *doubtfully*.
8. On page 114, 13th and 14th lines, for "Chicamauga," read *Chickamauga*.
9. On page 157, 15th line, after "and" supply *the tests*.
10. On page 229, 23rd line, for "second terrace," read *first Pleistocene terrace*.
11. On page 245, in the heading, for "COSTAL," read *COASTAL*.
12. On pages 257 and 259, page headings, for "KOALINS" read *KAOLINS*.
13. On page 350, 12th line, for "Starrville," read *Starrsville*.
14. On page 400, 20th line, for "was," read *is*.

THE ADVISORY BOARD

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,
ATLANTA, February 5, 1909.

To His Excellency, HOKE SMITH, *Governor and President of the Advisory Board of the Geological Survey of Georgia.*

SIR: I have the honor to transmit herewith for publication the report of Mr. Otto Veatch, Assistant State Geologist, on the Clay Deposits of Georgia. This report is the second report published by the State Geological Survey on this subject. The first report, published in 1898, was confined entirely to the Cretaceous clays along the Fall Line, whereas this report includes not only the Fall Line clays, but also the clays of all parts of the State. The large amount of valuable information brought together in this report will be, no doubt, of great value, not only to the clay prospectors, but will also be the means of calling the attention of clay manufacturers to our high grade kaolins and fire clays which occur in great abundance.

Very respectfully yours,
S. W. MCCALLIE,
State Geologist.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PLATES

FIGURES

MAPS

PREFACE

The following is the second report on clays issued by the Geological Survey of Georgia. A report was issued in 1898 by Dr. Geo. E. Ladd on a part of the clays of the State; this report was concerned only with the clays along the Fall Line, and it was then the intention of Prof. W. S. Yeates, late State Geologist, to publish a second bulletin covering the entire State. This work was entrusted to me and the accompanying report is submitted as the result of my labors. Since the publicaion of Dr. Ladd's report, much development work has been done and new uses for the clays have been discovered, and it was thought best to re-survey the region covered by him. Many inquiries concerning the clays of the State have been received by the Geological Department, both from citizens of the State and investors from other States and it is hoped that the present report will supply these demands for information.

The field work of the report was done by the author, and all of the principal clay localities and plants manufacturing clay products in the State were visited in person. The time consumed by this work was much more than was anticipated in the beginning. In addition to the description of known clay localities, much purely geological work and exploratory work was done. As a result of my geological work a map of the Cretaceous formations of Georgia is presented. But little geological information has hitherto been published concerning the Cretaceous in western Georgia, and the formation had not been subdivided and mapped.

The physical tests accompanying the report are, with the exception of those on specific gravity, the work of the author. It is regretted, that they could not be made more complete, but neither the time nor the laboratory equipment was available. The excellent chemical analyses in the report were made by Dr. Edgar Everhart, Chemist of the Geological Survey, except when otherwise specified. Dr. Everhart also made the specific gravity tests.

For the arrangement and manner of presentation, the author is responsible. The first part of the report contains general information, such as has been largely published in. reports on clays by other State surveys. It was believed that such was necessary to an intelligent understanding of the subsequent part of the book, and the data concerning the origin, physical and chemical properties has been presented in as concise a manner as possible, and technical detail omitted.

Detailed description of clay working plants—manufacturing processes, machinery, kilns, personel, etc.—are omitted as not being with the province of this report. Such descriptions would only make the report unduly bulky. It will be found that a number of the counties in the State are not mentioned. Such counties are either remotely situated or contain no known clay deposits likely to be of value. On account of the large field to cover, exploratory work in these counties could not be undertaken.

Throughout the progress of the field work manufacturers and property owners generally manifested interest and gave such assistance as was desired. Acknowledgement is made to Prof. S. W. McCallie, State Geologist, and Dr. Edgar Everhart, Chemist, for their helpful interest in the work.

The Clay Deposits of Georgia

CHAPTER I

CLASSIFICATION AND ORIGIN OF CLAYS

Definition.—The term clay is applied to earthy materials, which have the property of plasticity when wet, and are capable of being moulded and of retaining their moulded shape when dry, and have further the property of hardening when burned. Chemically and mineralogically, clay consists of a variable mixture of mineral fragments, an essential constituent of which is a hydrated silicate of alumina, kaolinite, or some allied mineral, which must be present before the mixture can have certain physical properties, requisite for its use in the manufacture of clay wares. Clays may exist as almost pure kaolinite or kaolins through all variations of purity, until they grade into sands, limestone, and other sedimentary rocks.

Origin.—All clays are of secondary origin and have been derived directly or indirectly from the decay and breaking down of the original igneous rocks of the earth's crust. This decay has taken place mainly through the atmospheric agencies, rain, frost, changes in temperature, wind, and through atmospheric gases and organic agencies, plants and animals, all of which may be included under the term *weathering*. The minerals of igneous rocks, which have been the chief source of kaolinite, or the *clay base* or *clay substance* of clays, are the feldspars. Other aluminous minerals, however, have doubtless been a source of the kaolinite of clays, and the following list of minerals has been noted by Prof. C. R. Van Hise[1] as having produced kaolinite through chemical alteration:

Andalusite, anorthoclase, biotite, cyanite, epidote, leucite, microcline, nephelite, orthoclase, plagioclase, scapolite, sillimanite, sodalite, topaz and zoisite.

The most probable chemical reactions taking place when the feldspars are altered to koalinite are given by Van Hise[2] as follows:

ORTHOCLASE—

$$2KAlSi_3O_8+2H_2O+CO_2=H_4Al_2Si_2O_9+4SiO_2+K_2CO_3.$$

ALBITE—

$$2NaAlSi_3O_8+2H_2O+CO_2=H_4Al_2Si_2O_9+4SiO_2+Na_2CO_3.$$

ANORTHITE—

$$4CaAl_2Si_2O_8+3H_2O=H_2Ca_4Al_6Si_6O_{26}+H_4Al_2Si_2O_9$$

The composition of kaolin is—$H_4Al_2Si_2O_9$, or Al_2O_3, $2SiO_2$, $2H_2O$, which represents a percentage of 39.8% of alumina, 46.3% of silica, and 13.9% water.

In addition to the alteration of feldspar by weathering, it seems probable that it may also be altered by pneumatolysis or by the action of ascending acidic vapors. The kaolin of Cornwall, England, has been attributed to action of this kind.

Weathering agencies tend to break down and decompose igneous rock masses, by kaolinizing the feldspars and other aluminous minerals, decomposing or taking into solution others while still other more stable minerals are left as mechanical detritus. The residual or disintegrated mass from weathering, consisting of clay and more or less decomposed mineral fragments, is taken into suspension by running water and deposited in flood plains, lakes, estuaries and seas. The clay of the residue is deposited as kaolin or, together with many mineral impurities, as impure, laminated clays and

[1]Treatise on Metamorphism, p. 352.
[2]Treatise on Metamorphism, p. 253.

shales, and is contained in small percentages in other sedimentary rocks as limestones and sandstones. These sediments may become land surface and are themselves subject to weathering and decay, and through the same process as above, secondary deposits of clays are formed from them. The origin of the main classes of clays will be discussed in detail in the following pages.

CLASSIFICATION OF CLAYS

The following classification of clays is given from the point of view of origin. A classification of clays may also be made upon the basis of uses and physical and chemical properties, and is perhaps more desired by the clay worker than the former; but the genetic classification is here given, since it is regarded as essential to the understanding of the primary divisions of clays, and ultimately the technological classification itself is based upon the genetic classification, and is not clearly understood until the reader has some knowledge of the origin of clays.

The classification here given is a modification of numerous others given by geologists and clay technologists.

1. RESIDUAL—
   - A. Kaolins. } Resulting *in situ* from the decay of both igneous and sedimentary rocks.
   - B. Impure clays. } Resulting *in situ* from the decay of both igneous and sedimentary rocks.
   - C. Semi-residual deposits.
2. TRANSPORTED—
   - A. Sedimentary deposits.
     1. Marine and Estuarine.
        - a. Shales and slates.
        - b. Kaolins and fire clays.
        - c. Impure or red burning clays, unconsolidated.
     2. Lacustrine.
        - a. Shales and fire clays.
        - b. Impure and calcareous clays.
     3. Stream.
        - a. Alluvial clays.

B. Glacial deposits.
   1. Bowlder clays.
   2. Glacio-fluvial deposits.

C. Gravity assisted by water, or colluvial deposits.

D. Wind deposits.
   1. Loess.

3. CHEMICAL DEPOSITS.
   1. Flint clays (in part).
   2. Bauxitic clays (in certain localities).

RESIDUAL CLAYS

Residual deposits of clays are those clays which are left as a residue of the decay of rock and which occupy more or less closely the position of the rock from which they are derived—those clays which have not been removed by meteoric agencies from their place of origin. They may be derived from any variety of sedimentary or igneous rocks and hence have extreme variations in chemical and mineralogical composition and physical properties.

The process by which rocks are converted into residual clay deposits is called *weathering*. Weathering is produced by both chemical and physical changes, and the agencies effecting these changes are the atmosphere, water, and plant and animal life. The atmosphere exerts both a chemical and mechanical effect in disintegrating and decomposing rock masses. The atmosphere is laden with gases, which are taken into solution in the moisture of the air, and then exert a chemical effect upon the minerals of rocks. Carbon dioxide, CO_2, is widely distributed in the atmosphere, and this, when taken into solution by rain waters, exerts a strong solvent effect upon minerals and rocks. The oxygen of the atmosphere also enters into combination with elements of rocks and exerts a disintegrating effect. Oxidation is especially noticed in connection with iron minerals. By changes in temperature, heat and cold, and by the wind, great mechanical or disintegrating effects are brought about. Expansion and contraction from heat and cold set up strains in minerals which gradually result in a breaking up of the rock. Rain water is the most important agency in weathering; even pure water exerts a solvent effect upon minerals, and this is increased by acids taken from the atmosphere and those derived from plants and animals. The dropping of rain also exerts a mechanical effect in moving disintegrated rock particles and producing friction and wear of one particle over another. Plants and animals also produce both a chemical and physical effect in bringing about the destruction of rocks. The decay of vegetable matter liberates organic acids which aid the decomposing effect of water, and the growth of roots of trees are observed to fill crevices and disrupt or pry apart blocks of rocks. Certain animal life is also thought to exert an important effect in the decomposition of rock.

The form and character of a residual clay deposit, resulting from the processes of weathering above enumerated, will depend upon the form, chemical composition, and texture and structure of the rock from which it was derived.

Residual Kaolins.—Kaolin is the term applied to those clays which are white in color, which burn white and approach the mineral kaolinite in composition. Commercially they are the most valuable clays, being used extensively in the manufacture of chinaware, porcelain, paper, etc. They may be both of residual and sedimentary origin. Both types of deposits occur in Georgia. The residual kaolins are derived chiefly from the decomposition of the feldspars of coarse granites or pegmatites, but may also be derived from sediments, generally limestone, although it is possible for residual kaolins to result from shales or schists and arkosic sandstones.

In the formation of a residual kaolin from weathering, a coarse granite or pegmatite may be taken for illustration.

The granite is composed chiefly of feldspar (orthoclase), quartz and mica. By the processes of carbonation and hydration the feldspar is decomposed and converted into kaolinite, with a loss of silica and potash; the quartz of the granite is disintegrated and may be in a very finely divided state, but is not greatly affected chemically and remains in the kaolin as a mechanical impurity or sand; the mica is disintegrated and exists in the residual mass as small silvery flakes, but it is not improbable that the mica itself through chemical alteration has produced some kaolin. There may be minor accessory minerals such as magnetite, garnet, apatite and zircon, which may or may not be altered by the weathering agencies, but on account of the amount present, they exert little effect upon the purity of the residual mass. When biotite, or iron bearing micas, occur they are oxidized and iron oxide derived from them, forms an impurity in the residual clay. The result of the weathering is a friable mass of more or less pure kaolin with a large percentage of quartz sand and other undecomposed minerals. The form and extent of a deposit will depend upon the form and extent of the rock from which it was derived. It may be in the form of veins, sheets, pockets or may be derived from an intrusive mass or boss extending over wide areas. In granites and other feldspathic rocks complete kaolinization has often taken place to depths of 100 feet, beyond which the feldspars are undecomposed.

Residual kaolins derived from granitic rocks are observed throughout the Crystalline area in Georgia, but no deposits have yet been exploited and worked on a commercial scale.

Residual Kaolins From Sedimentary Rocks.—Extensive deposits of white clays approaching kaolins in composition are known to be derived from the weathering of sedimentary rocks. Quite pure, white clays derived from hydro-mica slates occur in Pennsylvania, and Wheeler describes deposits of kaolin resulting from decay of Cambrian, Ordovician and

Carboniferous limestones in Missouri. In Georgia, in the areas underlain by the Knox dolomite formation, there are deposits of white clays which are undoubtedly residual in origin. The most probable explanation of these deposits is that the kaolin was contained in the original rock as an earthy impurity and was not derived from the alteration of minerals in the rock. The clay might have occurred in cavities in the limestone or may have been disseminated as fine aluminous matter. In the processes of sub-aerial decay, the soluble portions of the rock were carried away in solution and insoluble impurities such as clay, chert and iron were left as a residue. The essential conditions for the formation of residual kaolin deposits derived in such manner are that the clay residue be in such a position that it will not be transported in suspension by running water, and that the original rock does not contain a high percentage of insoluble impurities. Such impurities as lime, magnesia and the alkalies would be largely removed in solution and would not greatly affect the purity of the clay. It must be borne in mind that while deposits derived from sediments may be directly residual, the primary source of the clays is from the decay of igneous rocks.

IMPURE RESIDUAL CLAYS.—Impure residual clays may be derived from all varieties of rocks igneous or sedimentary, and consequently have wide variations in color, texture, and physical properties and extreme variations in chemical composition. The most common impurity in such clays is iron, which is also the chief coloring agent. Impure residual clays may be high in lime, alkalies or magnesia, depending largely upon the chemical composition of the rock from which they were derived. These clays may be highly ferruginous, quite siliceous or sandy, and very calcareous. Their origin is similar to that of the residual kaolins, being due to the decomposition and disintegration of rock masses by weathering.

Residual clays are of wide distribution and frequently occur in considerable thickness, and form brick and pottery clays of much economic value. The residual clays of the Piedmont region are a conspicuous bright red on account of their iron content. They are derived from the decay of the crystalline rocks, granites, schists, diorites, etc. The residual clays of the Paleozoic area are derived from limestones, sandstones and shales. Those from the limestones are usually red in color though they may be bluish, yellow or even white and usually possess good plasticity, except in cases where the limestone was cherty and they are, then, highly siliceous. The shales produce red, yellow, and light colored plastic clays. Those derived from the sandstones, sandy shales and quartzites are so highly siliceous that they are of no economic importance. The Coastal Plain of Georgia is composed of comparatively recent sediments and has not been subjected to weathering for such great periods of time as the older rocks have, and also, from the fact that the rocks are for the most part friable sands and clays, its residual clays are inconspicuous.

Semi-Residual Clays.—In the Piedmont Plateau there are ancient, highly metamorphosed sediments, probably originally shales, which are considerably decomposed but which still retain their structure and are not completely disintegrated. These rocks, where unaltered, have lost their plasticity through metamorphic changes and are valueless for clay products. However, by partial decomposition, mainly of aluminous minerals, they are of some economic value. Such deposits can hardly be termed residual clays, since the rock preserves to some extent its orginal structure. The above conditions apply equally well to schists of doubtful origin, and hence such clays could hardly be termed sedimentary clays. For this type of clay, Mr. Earle Sloan, State Geologist of

South Carolina, applied the term *Meta-residual*[1]. In Georgia, such deposits as that being mined at Belair in Richmond county and the so-called shale used for the manufacture of building brick at Bolton, in Fulton county, may be placed in this class.

TRANSPORTED CLAYS

SEDIMENTARY CLAYS

The clays and disintegrated rock masses produced by weathering do not always remain at their point of origin. The aluminous or clayey matter of residual deposits, together with more or less mechanical and chemical impurities, have been transported and deposited by running water, wind and ice, and form the second main division of clays, *transported clays*. When the mantle of residual material or regolith is taken into suspension by running water or streams, the sediment carried is deposited in flood plains, lakes, estuaries and seas. The clay deposits formed in this way are termed sedimentary deposits.

MARINE AND ESTUARINE DEPOSITS.—The clays which have been carried out to the bottoms of the seas and estuaries, or arms of seas, form stratified or bedded deposits of various types of clays. *Shales* are fine clay and mineral particles which have been carried far out into large bodies of still water and deposited as stratified or laminated muds of sometimes enormous thickness. By changes of elevations in the sea bottoms and by a change in the character of the sediment brought down by the streams, other sediments may be borne over the muds, the whole may become land surface, and through pressure and metamorphism the laminated muds are consolidated and become shales. When the beds of shale are

[1]Bull. No. 1, S. C. Geol. Survey, p. 21.

subjected to heat and pressure in the process of mountain making, they become metamorphosed into *slates* and *schists* and thereby lose the properties of clays. Also, by process of metamorphism the original minerals may be altered and rearranged and new minerals developed so that the resulting texture is quite different from that of the original deposit.

The term shale applies to structure rather than to chemical composition or mineral constitution, and shale clays may have a wide range in composition, varying from highly siliceous or sandy to very calcareous and bituminous. Enormous thicknesses occur; the Conasauga shale formation of Georgia reaches a thickness of 4,000 to 5,000 feet. Shales are used in the manufacture of all kinds of clay wares except chinaware and porcelain. They have properties similar to non-indurated clays, but do not possess plasticity until finely ground.

Some plastic kaolins and white fire clays occur as sedimentary deposits and are either of estuarine origin or were deposited in off-shore bodies of water. Typical of such deposits are the extensive beds of white cays of the Cretaceous and Tertiary formations of the Coastal Plain of Georgia. These deposits are generally soft, and massive bedded and do not show the laminated structure usually observed in sedimentary clays. They are derived from the residual clays of the highly feldspathic, crystalline rocks of the Piedmont Plateau, and were transported only short distances. The origin of the white clays of the Cretaceous in Georgia is discussed in detail on a subsequent page.

There are also extensive sedimentary deposits of marine origin which have been deposited in seas in a similar manner to shales, but which differ from shales chiefly in that they are unconsolidated. There are extensive deposits of such clays in the Cretaceous and Tertiary formations of the Coastal Plain. These clays may have a laminated structure and vary in composition and texture just as do the shales.

The laminated sandy clays and black clay-marls of the Upper Cretaceous, and the extensive fuller's earth formation of the Claiborne are good examples of such clays in Georgia. Unlike shales, however, they have not been consolidated and metamorphosed by pressure, and their plasticity may be developed without fine grinding. These clays may be calcareous, very sandy, or lignitic. They are chiefly of value for brick purposes.

LACUSTRINE CLAYS.—Residual clays and rock debris may be transported by streams and deposited in lakes and such sediments are similar to those deposited in seas, in being sorted and having a laminated and bedded structure. Lake clays of glacial origin are common in some of the Northern States, having been deposited in basins in front of the ice sheet, or in valleys dammed up by drift. Some deposits have been formed in swamps and bogs. This is generally supposed to be the origin of the fire clay deposits underlying coal seams, and their present purity is due to a leaching out of impurities by organic acids formed from the decay of vegetable matter. The impure plastic clays in swamps along the larger streams and near the coast in the Coastal Plain of Georgia belong to this division of clays. These clays are very fine grained, plastic and contain organic matter. They have been taken into suspension by running water flowing into the swamps, and are accumulated very slowly, since the land is flat and the streams are very sluggish and retain in suspension only the finest particles.

STREAM DEPOSITS OR ALLUVIAL CLAYS.—In the early stages of the existence of a stream its valley is narrow and V-shaped, and it has rapid flow or steep gradient. It is engaged in cutting *down* its channel, and the sediment which it carries in suspension is coarse and is used by the stream in corroding its channel in the rock over which it flows. The stream reaches a stage in its history when it ceases cutting *down* and it begins to widen its valley by cutting into its sides and flowing from one side of the valley to the other, thus forming a flat plain called its flood plain. At this stage, the river is sluggish, and only the clay and silty particles are carried in suspension. During flood periods the stream may be overloaded or contain more sediment than it can carry, and this is dropped in its flood plain to form alluvial deposits. The alluvium is derived from the residual material of rock decomposition just as all other sedimentary deposits are. Rainwater washes the soil and disintegrated rock into gullies and ravines, these enter small branches or tributary streams, and these in turn enter larger streams. The coarser material is deposited near the heads of the streams and the finer material along the lower courses; the coarse material is dropped first and the finer material remains in suspension longest. In times of flood, the streams spread over their plains, and the velocity of the stream being checked some of its sediment is dropped forming a mantle of silt and sand. This accumulation continues until great thicknesses of alluvial deposits are formed. From the origin of alluvial deposits, they would be expected to be quite variable in texture and structure. The clay of alluvial deposits is generally mixed with sand and is quite variable in extent and thickness.

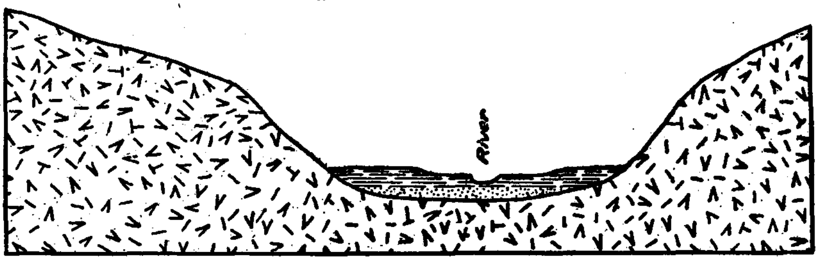


Fig. 1.—Sketch Showing an Alluvial Deposit of Clay.

Clay particles remain in suspension longest and are deposited only in comparatively still water, and much of the clay of alluvial deposits probably represents deposits from back water and cut-offs, and are in the form of pockets or lenses and not in continuous layers.

The character of the clay depends largely upon the nature of the rock formations over which the stream and its tributaries flow. To take concrete examples, the alluvial clays along the large streams in the Piedmont Plateau, contain a large percentage of quartz and mica sand and other undecomposed minerals derived from igneous rocks and the clay is bluish or gray in color, and is simply residual kaolin made plastic in the processes of transportation and deposition. They contain from two to six per cent. of iron and no lime or only a very small amount. Those streams which originate in the Coastal Plain, on account of the very sandy character of the rock over which they flow, do not produce any alluvial deposits of economic value.

Alluvial deposits furnish some of the most valuable brick and tile clays in Georgia.

Glacial Deposits

In that part of the United States which was covered by the continental ice sheet, there are deposits of impure clays which were transported by the ice. This material deposited by the ice is of a heterogeneous character, and consists of the ground-up rocks over which the glaciers advanced. Some deposits were formed which were partly water deposits. These are a redeposition of the drift, brought down by the ice, in streams and lakes, the water of which was derived from the melting of the ice.

Colluvial Deposits

Colluvial clay deposits differ from residual deposits in that they have not been carried in suspension by streams and are not flood plain deposits. They occupy a position midway between residual and alluvial deposits and may by gradual transition pass into either. They are due to the transportation of residual material, by gravity and wash to the foot of slopes. The factors in the formation of colluvial deposits are: 1, surface decay of rock masses producing residual deposits; 2, transportation of this residual material by gravity and wash; 3, rearrangement of the transported material by mechanical and chemical changes. To illustrate the formation of a deposit, take as an example a hill of residual material derived from a granitic rock. The section of the residue is, beginning at the top, red clay soil containing coarse quartz fragments, yellow to gray clayey residue, disintegrated rock, and finally unaltered rock. By wash from rainwater, the fine clay particles of the residue are carried furthest and lodged at the slope of the hill, forming the clay deposit. In granite regions, the clay at the foot of the slope may be almost white, gradually changing into the red and yellow soil higher up the slope.

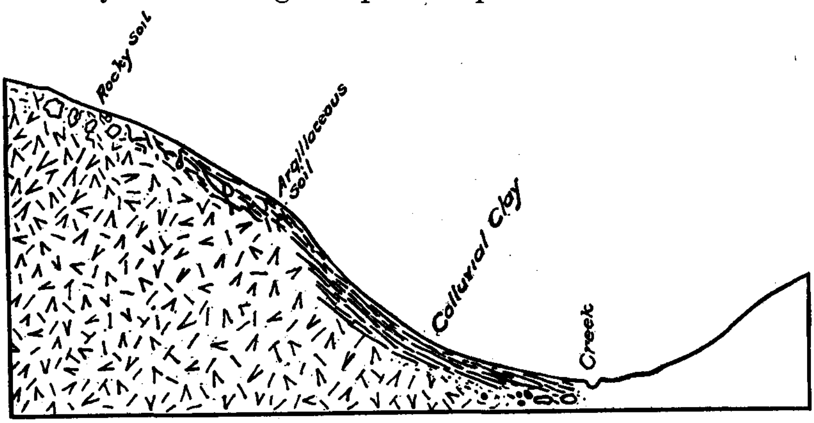


Fig. 2.—Sketch Illustrating the Formation of a Colluvial Clay Deposit.

Colluvial deposits furnish some very good brick and pottery clays throughout the Piedmont Plateau of the State. Such deposits, however, are usually small.

Wind Deposits

In the Mississippi and Missouri valleys, there are deposits of loess, which may have been in part deposited by wind action. The loess bears a relation to the ice sheets

FIG. 1.—ALTAMAHA SANDSTONE NEAR REGISTER.

FIG. 2.—ALTAMAHA SANDSTONE NEAR REGISTER.

and was derived from the sediments brought down by glaciers; it consists mainly of very fine sand grains, and only a small percentage of clay. It has been used in the manufacture of brick.

CHEMICAL DEPOSITS

From what has been said previously regarding the origin of clays, deposits of chemical origin would hardly be expected. Some commercially valuable clays are ascribed to this origin, however. Mr. H. A. Wheeler, who studied the clay deposits of Missouri, was of the opinion that certain non-plastic flint clays found in the limestones of Missouri, were chemical deposits, being primarily sedimentary deposits and altered subsequently by leaching and recrystallization. Certain bauxite clays, closely associated with bauxite, occurring in northwest Georgia, are, in the opinion of the writer, associated in origin with the bauxite. The bauxite deposits were studied by Dr. C. W. Hayes and Dr. T. L. Watson, and the most acceptable theory in their opinions, was that the bauxite was precipitated from a chemical solution.

Some white clays in the Cretaceous formation of the Coastal Plain were observed by the writer to have a perfect pisolitic and concretionary structure, and it is difficult to conceive how this structure could have originated, except from precipitation from a chemical solution. The clays are, however, sedimentary deposits which have been altered chemically, in place, most likely, and have not been transported in solution.

The halloysite deposits in Dade county, Georgia, represent probably a chemical alteration of residual kaolin. Small veins of halloysite are observed in altered granitic rocks in the Piedmont Plateau, and these are either a chemical alteration of residual kaolin derived from feldspars or an alteration of the feldspar itself.

CHAPTER II

MINERALOGICAL AND CHEMICAL COMPOSITION OF CLAYS

Minerals of Clays

Clay, if absolutely pure, would consist of aggregates of hydrated silicate of alumina alone, the mineral kaolinite, or some allied mineral. Absolutely pure clay, in commercial quantities, however, is not known, and the clay of commerce consists of aggregates of particles of minerals found in igneous and sedimentary rocks; of such aggregates, kaolinite, or some allied hydrated silicate of alumina, is an essential constituent.

Clays may exist as almost pure, as kaolins, or may be of complex mineral composition, or may consist predominantly of one mineral with only a very small percentage of clay. Thus clays may vary from 99 per cent. pure to those containing only 5 or 6 per cent. clay substance. The different minerals existing in clays may occur as oxides, carbonates, silicates, sulphates, etc., and different minerals have different chemical and physical properties and their presence in clays in appreciable amounts, exerts a peculiar influence upon the working and burning qualities of clays.

The following is a list of the more common minerals, which have been identified by various investigators, occurring in clay: quartz, orthoclase, plagioclase, muscovite, biotite, limonite, hematite, magnetite, pyroxene, hornblende, pyrite, siderite, calcite, garnets, manganese oxide, gypsum, rutile, ilmenite, tourmaline, glauconite and bauxite.

The kinds and quantity of minerals found in clay are determined by its origin, whether sedimentary, residual, etc., and the rocks from which it was derived. The list of minerals given above could doubtless be vastly augmented, and perhaps a greater part of all of the minerals known to occur in rocks might under peculiar conditions be found in clays, but such a list would be neither of practical nor of scientific value. Only those minerals which occur in commercially valuable clays and which have a direct bearing upon the properties of the clay or are of special mineralogic interest need be discussed.

KAOLINITE.—Kaolinite is a hydrated silicate of alumina. Its chemical formula is Al_2O_3, $2SiO_2$, $2H_2O$, which represents, alumina, 39.8 per cent., silica, 46.3 per cent., and water, 13.9 per cent. In its crystalline form, it is white or pearly and occurs in hexagonal plates. It has a hardness of 2 to 2.5 and a specific gravity of 2.2 to 2.6. The mineral is commonly regarded as the base of clays, though its presence in the crystalline form is rarely detected with certainty in clays. However, regarding kaolins as in the main being composed of aggregates of scales or plates of kaolinite, the mineral is plastic, and is highly refractory, having a fusing point near cone 36, or about 3,362° F.

Other hydrated silicates of alumina related to kaolinite are halloysite, pholerite, rectorite, allophane, and newtonite. Halloysite has been noted as occurring at several localities in Georgia. Halloysite is ordinarily non-plastic; not as earthy or friable as clay, and is compact enough to break with a conchoidal fracture; it usually has a waxy lustre and varies in color from pure white to greenish, yellow and red. It contains a higher percentage of combined water than kaolinite; the composition as determined by Le Chatelier and given by Dana is $2H_2O$, Al_2O_3, $2SiO_2$ + Aq. or silica, 43.5 per cent., alumina, 36.9 per cent., water, 19.6 per cent.

QUARTZ.—Quartz, either in crystals or in the amorphous impure form of chert or flint, is the most common mineral impurity in clays and may vary from less than one per cent. in very pure kaolins to 70 or 80 per cent. in impure brick clays and certain siliceous fire clays. As marking the extremes in the clays examined in Georgia, a very pure, sedimentary kaolin from Dry Branch showed 0.5 per cent. quartz, while a very siliceous fire clay, utilized for fire brick at Mission Ridge, showed 80 per cent. free silica or sand.

Quartz in clays affects their fusibility and behavior in burning, shrinkage, plasticity and tensile strength. It also detracts very much from the value of certain clays which are used in the raw condition, such as those used for paper filling.

Pure quartz has a fusing point of about 3,326° F. or near pyrometric cone, 35. Ordinarily considered it increases the refractoriness of a clay; this fact has been observed by every brick maker, for when his clay becomes sandier than usual a longer and greater heat is required to obtain a hard burned brick. At high temperatures, however, it has been proven by laboratory experiments, that silica acts as a flux. This was first proven by H. Seger, the famous German technologist. Mr. H. Ries, in his study of New Jersey clays, made similar experiments with a mixture of white burning clay and finely ground quartz, and obtained results agreeing with those of Seger, and deduced the conclusion that those fire clays, other things being equal, which contain the smallest quantity of free silica or sand are the most refractory. The size of the quartz particles also affects the fusing point, fine grains fusing more readily than coarse.

Quartz sand in a clay diminishes both the air and fire shrinkage. Sand added to a clay tends to make it more open and porous, and when the water used in mixing up the clay is expelled by evaporation, the clay particles can not draw as closely together as if the sand were not present and hence the shrinkage is lessened. In the burning of clays it has been observed that there is a diminution in the volume of the clay until the point of vitrification is reached. This shrinkage is due in the main to the fusion of mineral particles composing the clay; the quartz grains do not enter into this fusion at low temperatures and hence counteract the shrinkage. In some very sandy brick clays there may be an expansion rather than a contraction.

Quartz sand is a non-plastic material and when added to a clay lessens its plasticity. It is also known from laboratory and practical experience that sand lessens the air dried strength of clays, and hence a knowledge of the amount and character of sand present in a clay is essential to the successful working of a clay.

FELDSPAR.—Nearly all clays contain feldspar. Feldspar is a silicate of aluminum with potash or lime or soda. The mineral varies in color from white to pink, red, yellow and green; it is not as hard as quartz, being 6 in the scale of hardness while quartz is 7. Feldspar is not found in clays in as large particles or in as large amounts as quartz, since it does not resist abrasion in transportation or resist weathering to the extent that the latter mineral does. It is rarely found unaltered in clay and is cloudy from partial kaolinization. The highest percentage of feldspar in Georgia clays analyzed for this report was 38 per cent., while the average is probably not over 2 per cent.; in some of the plastic kaolins and bauxitic clays it is entirely absent.

Feldspar fuses at 2,012° F., to 2,198° F., but may act as a flux in clays at a lower temperature. In the manufacture of chinaware, porcelain, etc., feldspar is added to kaolins, to reduce their refractioness.

MICA.—Mica is found in nearly all rocks both igneous and sedimentary, either as an original or secondary mineral and since it is not easily decomposed by weathering agents and since it is readily carried in suspension by running water, it is a common constituent of clays. Muscovite and biotite are the varieties most commonly met with. Muscovite is a silicate of alumina and potash having a chemical formula, H_2KAl_3 $(SiO_4)_3$; this corresponds to silica, SiO_2, 45.2 per cent., alumina, Al_2O_3, 38.5 per cent., potash, K_2O, 11.8 per cent., water, H_2O, 4.5 per cent.

Biotite is a complex silicate of alumina, potash, iron and magnesia, and is of variable composition, but the formula, $(HK)_2$ $(MgFe)_2$ Al_2 $(SiO_4)_3$ is given by Dana as typical. Mica is present in clays in the form of thin, glistening scales or flakes; the biotite, which is black when fresh, is nearly always decomposed and the iron leached from it. Mica is present in nearly all shales and in some clays is the most abundant mineral impurity. The plastic white clays of the Cretaceous of Georgia all contain mica as a mineral impurity and it very often exceeds quartz in amount. On account of its usual fineness and ease with which it floats, it is difficult to eliminate it from clays by washing.

Mica acts as a flux in clays at high temperatures. However, it is stated by one investigator that if muscovite is ground extremely fine that it will vitrify sufficiently to produce a non-absorbent body below cone 4.[1] In the case of some micaceous brick clays, as those of the Piedmont Plateau, the mica flakes retain their individuality and appear on the burned brick as glistening scales, where the brick are not burned to vitrification. The fusing point of muscovite mica, when not in an extremely finely divided state, is about that of cones 7 and 8, and under certain conditions scales of mica may appear in a body burned even to this temperature. When iron bearing micas are present they exert some coloring action upon the burned clay. In the examination of the

[1] R. T. Stull, Transactions Amer. Cer. Soc., Vol. IV, p. 225.

fire clays of Georgia, the writer found that when the clays did not contain over 2 or 3 per cent. of mica, their refractory qualities were not appreciably affected. Likewise, the presence of a small amount of muscovite mica in a kaolin does not materially detract from its value.

LIMONITE.—Limonite is a hydrous oxide of iron having the chemical formula $2Fe_2O_3, 3H_2O$; or Fe_2O_3, 85.5 per cent. H_2O 14.5 per cent. It is the most common iron compound in clays; it is yellow, yellow-brown, or even black in appearance, and occurs in clays disseminated in fine grains, and then gives a uniform color to the raw clay, or, it may occur in the form of accretions or concretions and limonitic crusts and layers. It is not an original constituent of igneous rocks and when present in clays, has resulted from the alteration of other minerals. It has both a coloring and fluxing effect in the burning of clays. The presence of less than one per cent. is often sufficient to produce a noticeable color effect in a burned clay and hence is an injurious constituent of kaolins, which are required to produce pure white bodies. On the other hand for the production of lower grade clay products, as common brick, paving brick, sewer-pipe, etc., it may be a desirable constituent in clays on account of its coloring and fluxing action.

In many residual and alluvial clays, limonite is present in the form of small black or brown accretions about the size of buckshot or small marbles, and these if not finely crushed, affect the appearance of the burned product by causing a cracked or rough surface and fused, black splotches. Such concretions are especially noticeable in the alluvial clays of the Chattahoochee, Flint, Ocmulgee and Savannah rivers in the Piedmont Plateau and near the Fall Line.

HEMATITE.—Hematite is the anhydrous sesquioxide of iron, Fe_2O_3. It is distinguished from limonite by its red color and streak and greater hardness. It readily alters to limonite. It produces both a coloring and fluxing effect in clays.

MAGNETITE.—Magnetite, Fe_3O_4, magnetic iron ore, is not common in clays. Magnetite is an original constituent of igneous rocks and is no doubt present in residual clays derived from igneous rocks. It has been observed in the form of minute black grains in some of the plastic sedimentary kaolins of Georgia, and may be partly the cause of the minute black specks observed when these clays are burned. It is, however, rarely present in clays in sufficient amount to materially effect the value of the clay.

SIDERITE.—Siderite, the iron carbonate, $FeCO_3$, occurs in some shales, either in concretionary masses or disseminated. It has been observed in some of the Coal Measure shales in Georgia. In burning, the siderite would be converted into iron oxide, with the expulsion of CO_2, carbon dioxide.

PYRITE.—Pyrite the iron sulphide, FeS_2, is very frequently found in clays and shales and is an injurious ingredient. It is pale yellow to brass color, has a metallic lustre and occurs in cubes or nodular lumps. In burning, the pyrite may be converted into iron oxide and sulphur dioxide, SO_2, which latter uniting with steam forms sulphuric acid, H_2SO_4. The sulphuric acid may unite with lime and magnesia compounds producing soluble sulphates which appear on the burned product as an efflorescence. When scattered grains occur, it may produce a splotched or speckled effect, similar to that produced by manganese.

Pyrite occurs in some of the shales of northwestern Georgia and is often very noticeable in the black and gray clay-marls of the Cretaceous and Eocene formations in the Coastal Plain.

LIME CARBONATE.—Lime carbonate, $CaCO_3$, occurs in clays in crystals as calcite, in the form of nodular concretions, or as fragments of limestone. Calcite is a soft, translucent to opaque mineral, and occurs in rhombohedral crystals. Lime carbonate when present, as much as 3 or 4 per cent. may be detected by its effervescence with acids, or even with strong vinegar. Lime carbonate is found both in residual and transported clays—crystals of calcite are observed in shales and their metamorphosed equivalents, while calcareous concretions and fragments are found in residual and alluvial clays. Lime carbonate in clay acts as a flux, and when present in any large amount produces a very rapid vitrification and hence is objectionable in clays used for sewerpipe and paving brick. When burned it is converted into quicklime which slakes upon exposure and causes a cracking of the ware. If the lime carbonate is disseminated through the clay or finely crushed it will not injure the clay for ordinary wares.

Concretions and fragments of lime carbonate were observed in the alluvial clays at Abbeville and Albany, where they have given some difficulty in the manufacture of brick. A rather unique occurrence of the concretions is at Union Point, where they occur in a residual clay derived from an igneous rock. In this case the lime carbonate was probably derived from the carbonation of hornblende, a silicate of lime, magnesia, and iron.

Gypsum.—Gypsum is a hydrous sulphate of lime; it is a soft mineral and can be scratched with the finger nail. It has a pearly lustre and occurs in plate-like crystals or in a fibrous form, and does not effervesce in acids. It is not of wide-spread distribution in clays, but when present is an injurious ingredient. Gypsum is not an original constituent of igneous rocks but is formed as a chemical precipitate from the ocean and salt lakes or lagoons. It may be of secondary origin in clays and is formed by the action of sulphuric acid upon lime carbonate. This mineral is most likely to be found in Coal Measure shales where conditions were more favorable for its formation; it does not occur in alluvial clays nor has its presence been noted in kaolins.

It was observed by the writer in small amounts in the sandy clay-marls of the Cretaceous of Georgia, but was not seen in appreciable quantity in any other clays.

RUTILE.—Chemical analyses show that titanium dioxide is almost universally present in clays and the source of this is commonly attributed to rutile, TiO_2. Rutile occurs in crystalline rocks and is a common secondary mineral in the form of *microlites* or minute needles. It has a hardness of 6 to 6.5 and would be very resistant to weathering and to abrasion in transportation. Rutile in the form of needles has been observed with certainty in some shales and schists. All of the analyses of Georgia plastic kaolins and fire clays and bauxitic clays showed percentages of titanium dioxide ranging from 0.08 to 9.25 per cent., though no rutile or any other titanium bearing mineral has yet been positively identified in them. Ground rutile mixed with a white burning refractory clay lowers the fusing point of the clay. According to experiments made by Mr. H. Ries[1], it was observed that one-half per cent. of rutile lowered the fusing point of the clay half a cone, and that 5 per cent. of rutile lowered it 2 cones. It is also known that ground rutile produces a yellow coloration in kaolins at low temperatures.

In testing the Georgia plastic kaolins and the kaolins associated with the bauxites, the writer was unable to detect any appreciable color effect or lowering of the fusing points of the clays, due to the percentages of TiO_2 shown in the analyses. It is highly probable that the titanium dioxide of these clays is not derived entirely from rutile.

HORNBLENDE AND PYROXENE.—These minerals are silicates of calcium, magnesia, and iron and are original constituents of igneous rocks, and may occur in the residual clays derived

[1]Clays of N. J., Geol. Surv. of N. J., p. 70.

from these rocks. The decomposition of hornblende is the cause of the deep red color of some of the clay soils of North Georgia. Either the hornblende or pyroxene if present in clay in any large quantity would be active fluxes. It is not improbable that some of the minute black specks observed in the white clays of the Coastal Plain are due to unaltered particles of hornblende or pyroxene.

GLAUCONITE.—Glauconite is a hydrated silicate of potash and iron, and occurs as green, sandy grains. It fuses at low temperatures and hence has a fluxing effect in clays; it also produces a color effect on account of the iron. Glauconite appears in the clays of the Upper Cretaceous and Lower Eocene in Georgia, but none of these clays have yet been utilized for manufacturing purposes.

BAUXITE.—Bauxite is a hydrous oxide of alumina, probably having the chemical formula Al_2O_3, $2H_2O$. It is a valuable ore of the metal aluminum. It forms a varying percentage of the bauxitic clays of Northwest Georgia and is also closely associated with clays at the newly discovered localities in Wilkinson county. Bauxite is very highly refractory and increases the fusing points of clays. It lessens the plasticity of a clay and causes it to crack in burning on account of the high percentage of combined water which it contains.

MANGANESE.—Oxides of manganese were observed in Georgia clays, but not in quantity to exert any appreciable chemical or physical effect in the working or burning of the clays. Manganese oxide, probably pyrolusite, occurs as stains along joints and occasionally in small lumps in the white clays of the Cretaceous. It would be an injurious ingredient in those clays used in the manufacture of white ware.

THE CHEMICAL ANALYSIS OF CLAYS

There are two commercial analyses made of clays—the *ultimate* and the *rational*. In the ultimate analysis the constituents of a clay are given as oxides of various elements, although the mineral components of the clay may exist as carbonates, silicates or sulphides. The rational analysis is an attempt to resolve a clay into its mineral components. The chemical analysis is of practical value to the clay worker when rightly interpreted, but an opinion as to the value of a clay is liable to error if based entirely upon it, and the analysis should be supported by physical tests. The rational analysis is of value only in the case of those clays used in the manufacture of the higher grades of clay wares.

The following is the form of the ultimate analysis:

Constituent	*Formula*	*Percentage*
Silica,	SiO_2	———
Alumina,	Al_2O_3	———
Iron (Ferric),	Fe_2O_3	———
Iron (Ferrous)	FeO	———
Lime,	CaO	———
Magnesia,	MgO	———
Soda,	Na_2O	———
Potash,	K_2O	———
Titanium dioxide,	TiO_2	———
Water (combined),	H_2O	———
Moisture,	H_2O	———

In the rational analysis only three constituents are determined:

Clay substance	———
Quartz	———
Feldspar	———

SILICA SiO_2.—Silica is given in most clay analyses as "combined" and "free." By "combined" silica is meant the silica in combination with kaolinite, or the clay base, and the silica of other silicates, which may be present, which are decomposed by sulphuric acid. Quartz and other silicates are given as free silica or sand.

The amount of silica shown in analyses of clays presents wide variations. Theoretically pure clay or kaolinite would contain 46.3 per cent. silica. The range in 125 analyses of Georgia clays was from 25.83 per cent. to 85.00 per cent.

Brick clays usually contain the highest percentage of total silica since they generally contain a large amount of free silica or sand.

The effect of quartz or free silica in clays has been discussed. Other silicates as hornblende, mica, garnet, feldspar, etc., may be the source of a part of the total silica of the analysis. These minerals, if present in appreciable quantities, may lower the fusibility and the shrinkage of clays. The ultimate analysis, however, does not determine the particular varieties of silicates present.

ALUMINA, Al_2O_3.—The alumina of the analysis is considered as the alumina of the clay base. In clays containing feldspars and other aluminous silicates, however, it is very probable that these yield a part of the Al_2O_3, of the analysis. In some clays, bauxite, Al_2O_3, $2H_2O$, is present. The range of alumina in Georgia clays was from 7.34 per cent. to 48.22 per cent., the lowest in a fuller's earth the highest in a clay from Rome, containing free bauxite. The percentage of alumina in pure clay, commonly regarded as kaolinite, would be 39.8 per cent.

IRON.—Iron is given in the ultimate analysis usually as the ferric oxide, Fe_2O_3, but the ferrous iron, FeO, is also frequently determined. This iron is derived from the iron minerals in clay, as limonite, hematite, pyrite, siderite, etc., and the silicates, biotite, hornblende, garnet, glauconite, etc.

Iron is a strong coloring agent both in the raw and unburned clay. It produces a great variety of colors in burned clay—from very faint cream to yellow and buff, all shades of red, brown, blue and even black. The amount of iron as shown by the ultimate analysis is not always by any means an index as to the depth of color which the burned clay will show. As an example a clay from Wilkinson county showing 11.73 per cent. Fe_2O_3 in the analysis, did not burn to as deep a color as an alluvial brick clay from Georgetown showing only 3.74 per cent. of iron. The Wilkinson county clay is a natural mixture of almost pure kaolin and iron oxide, while the Georgetown clay is a very sandy, alluvial clay. Aside from the quantity of iron oxide present, various factors affecting the color which it will produce are: 1. Texture and distribution of the iron in the clay; 2. Form of the iron; 3. Kiln conditions in burning, whether oxidizing or reducing, and temperature; 4. Chemical combination with certain other constituents of the clay which neutralizes the color effect of the iron. In the first case, it is readily seen that the color effect produced will be quite different, when the iron is in a finely divided state and intimately disseminated through the clay and when it exists in coarse grains and unevenly distributed. It is also important to know whether the iron exists in the clay in a ferric or ferrous form, whether for example as limonite, or as some ferrous silicate as biotite or hornblende. In burning, the kiln atmosphere may be either oxidizing or reducing. In the former case the iron is converted into the ferric form and in the latter case to the ferrous, with different shades of color resulting. The effect of differences in temperature may be observed in the burning of any ferruginous brick clay in the ordinary updraft kiln. The brick may vary in color from pale salmon at the top, to red in the centre and purplish and black near the eyes of the kiln.

The combination of iron oxide and lime in the burning of a clay is known to produce a buff or yellow color. As to whether the formation of alumina-iron compounds takes place in burning and neutralizes the red color of iron seems to be debatable. The writer observed, in the investigation of Georgia clays, that certain bauxitic clays from Northwest Georgia did not show as great a tinge of color as some of the plastic, white clays from the Cretaceous, though having a higher iron content. This fact, however, can not be attributed with certainty to the higher alumina content in the bauxitic clays. As a laboratory experiment, a mixture of clays was made in which the content of iron oxide, Fe_2O_3, was kept constant, 5 per cent., and the amount of alumina in the mixture increased, by the addition of pure aluminum oxide, from 36.78 per cent. to 50.18 per cent. Bricklets were made of the mixture and burned as near as possible under the same conditions to cone 4. The result was a very perceptible increase in depth of color from the highest alumina to the lowest, the shades ranging from the faintest pink to buff. The same series was burned at cone 11, and all burned to a rather leathery buff with no decisive differences in the depth of color. A rather interesting result of the experiment was that under certain conditions a clay mixture containing as much as 5 per cent. of Fe_2O_3 may be burned at a high temperature and show scarcely any color. Analyses of the separate mixtures were not made, but the chemical composition of the three constituents was known and the percentage of iron thus calculated.

Iron compounds in clays exert a fluxing action, not only because their individual melting points are lower than that of the clay base, but because it is believed that iron oxide enters into combination with silica forming an easily fusible silicate.

Iron in clays may be either a desirable or an undesirable constituent. In the lower grades of wares it is of value both as a fluxing and coloring agent, while the presence of less than one per cent. in kaolins may impart sufficient color to destroy the commercial value of the clay.

LIME.—The lime of the chemical analysis does not exist in the clay in the form of an oxide, but is derived from the lime minerals of clays such as calcite or limestone, dolomite and gypsum, and the lime silicates, as feldspar and hornblende, may contribute a small amount. Lime is an active fluxing agent in clays and when in excess of iron may unite with this latter mineral and neutralize its color effect.

The amount of lime in 125 analyses of Georgia clays ranged from 0 to 13.89 per cent. Common brick clays may contain a very high percentage of lime without their value being materially affected, provided that the lime, if in the form of the carbonate, is in a finely divided condition. It is injurious in paving brick and sewer-pipe clays if in large quantity, since it produces rapid vitrification.

MAGNESIA.—The magnesia, MgO, of the ultimate analysis is derived mainly from magnesian silicates of crystalline rocks, such as hornblende, biotite, etc., and the double carbonate of magnesia and lime, dolomite. It is rarely present in clays in large quantity. The amount in 125 analyses of Georgia clays ranged from nothing to 5.86 per cent.; the average in 52 kaolins and fire clays was only 0.07 per cent.

Magnesia exerts a fluxing action in the burning of clays. The work of a German investigator, Mackler, and in this country of Mr. Adolph Hottinger[1] has shown that magnesia is a less powerful flux than lime and in clays carrying magnesia, the vitrification and melting points are farther apart than in lime clays. Also that kaolin with magnesia gave a denser body at the same temperature than with lime.

In view of these experiments it can hardly be considered an injurious ingredient of clays, except in the case of fire clays where it is in sufficient amount to exert a fluxing action.

SODA AND POTASH.—Soda and potash, in the clay analysis, are given as the oxides, Na_2O and K_2O. It is doubtful whether the compound Na_2O exists; K_2O, may be produced artificially, but does not exist in nature. Soda and potash are derived mainly from the silicates, feldspar and mica. In some Tertiary and Cretaceous clays of the Coastal Plain, potash may be derived to some extent from glauconite, a sil-

1. Trans. Amer. Cer. Soc., Vol. V, p. 130.

icate of potassium and iron. The feldspars are silicates of alumina and potash or lime and soda; orthoclase, the potash feldspar, contains 16.9 per cent. of potash, while the lime-soda feldspars, oligoclase, andesine and labradorite contain from 4.5 per cent. to 14.2 per cent. of soda. Albite, the soda feldspar, contains 11.8 per cent. soda. Muscovite contains 11.8 per cent. of potash; paragonite is a soda mica, but has not been observed in clays.

Soda and potash, commonly termed *alkalies,* are regarded as the most powerful fluxes in clays. Brick clays usually contain the highest percentage of alkalies and in such clays, if in the form of silicates, the alkalies are a desirable constituent. In fire clays, if the alkalies exceed one or two per cent., the fusing points of the clays are apt to be materially lowered. The presence of a small per cent. of soda and potash in kaolins is not necessarily injurious, and when derived from feldspar would on the other hand be desirable. The average amount of soda in 52 Georgia kaolins and fire clays was .09 per cent.; the average amount of potash was .16 per cent. The average in 123 clays of all kinds was soda .27 per cent., potash, .83 per cent.

TITANIUM.—Titanium in clays is in reality of common occurrence, though it is often regarded as an uncommon constituent. From data collected by H. Ries[1], the common occurrence of titanium in clays is shown by the following list:

Twenty-one New Jersey clays................	1.06 to 1.93 %
A series of Pennsylvania clays...............	0.85 to 4.30 %
Eleven Ohio coal-measure clays..............	0.16 to 1.68 %
Fire clays from St. Louis....................	1.00 to 1.91 %
Thirty-five clays from Virginia...............	0.00 to 1.88 %
One hundred Texas clays......................	0.00 to 2.12 %

To this list may be added:

Seventy clays from West Virginia.............	.46 to 2.82%[2]
Twenty-two S. Carolina fire clays and kaolins.	.37 to 1.82%[3]
One hundred and seven Georgia clays..........	.04 to 9.25%

1. Clays, Occurrence, Properties and Uses, p. 84, John Wiley & Sons.
2. West Virginia Geol. Surv., Vol. III, 1905.
3. S. C. Geol. Surv. Bulletin No. 1.

The average of the 107 Georgia clays was 1.33 per cent.; in 52 kaolins and fire clays the average was 1.64 per cent.

Rutile, TiO_2, and ilmenite $(TiFe)_2O_3$, are regarded as the most probable sources of the titanium dioxide of the chemical analysis. Other possible sources are from titanite, CaO, TiO_2, SiO_2=Silica, 30.6 per cent., titanium dioxide, 40.8 per cent., lime, 28.6 per cent., and perovskite, $CaTiO_3$=lime 41.1 per cent., titanium dioxide, 58.9 per cent. Brookite and octahedrite are of the same composition as rutile.

Many of the plastic kaolins of the Cretaceous contain more titanium dioxide than all of the other impurities combined. Microscopic examination was made of these clays to determine if possible the source of the titanium. However, no titanium bearing minerals were identified with any certainty. Dr. T. L. Watson[1] made examination of the bauxites of Northwest Georgia, which contain high percentages of titanium, and no titanium bearing minerals were recognized. It seems likely that the titanium is connected with the origin of the bauxites which are of chemical origin.

The writer ventures to suggest that some of the titanium of the analyses of the white Cretaceous clays is in chemical combination with the aluminum silicate or clay base and does not exist as a free oxide.

Ground rutile mixed with kaolins is known to produce a fluxing effect and a yellow coloration at high temperatures. The writer was unable to observe in the investigation of the Georgia kaolins, that the percentages of titanium dioxide shown in the chemical analyses, appreciably affected either the color or the fusing points of the clays.

WATER.—Water is given in the analysis as *moisture* or *hygroscopic* water and *combined* water. Water absorbed from the atmosphere is retained in the pores of the clay but is not in chemical combination and is expelled from the clay at 100° C. In the natural state clays may contain as much

1. Geol. Surv. of Ga., Bull. No. 11, p. 52.

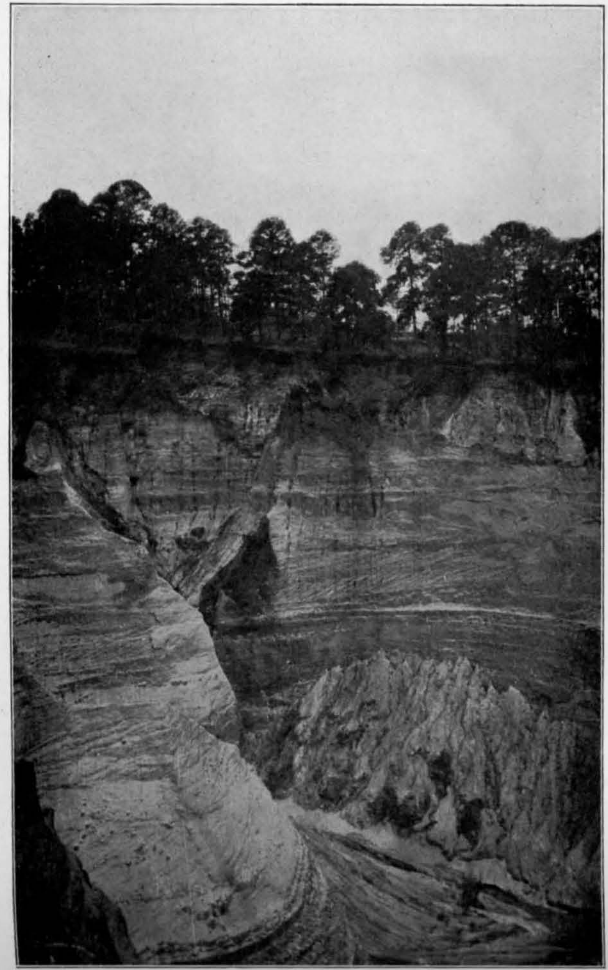


FIG. 1.—CROSSBEDDED SAND NORTH OF LUMPKIN.

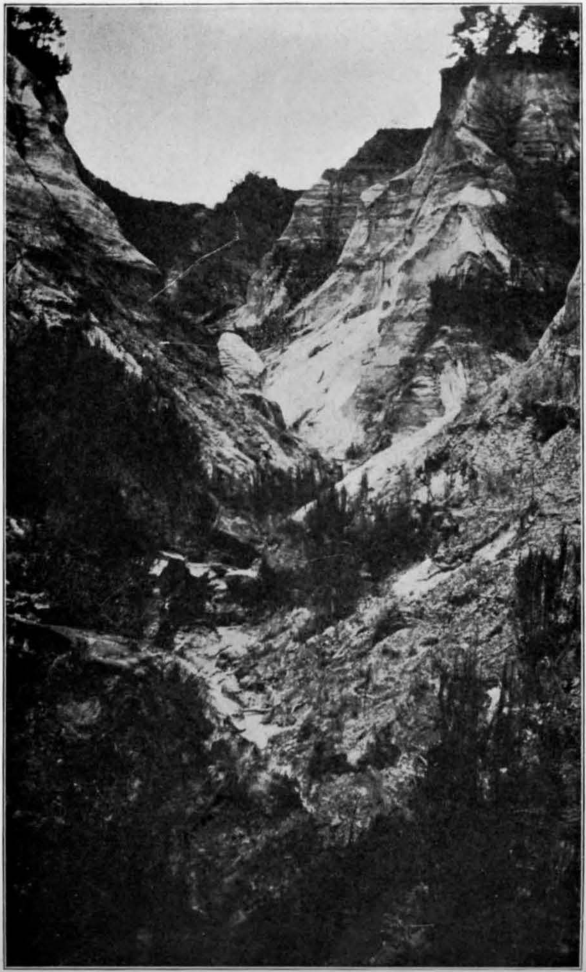


FIG. 2.—MCKEATHEM GULLY, 6 MILES NORTHWEST OF OF RICHLAND.

as 15 or 20 per cent. of water and in some exceptional cases as much as 50 or 60 per cent. without becoming soft mud. In air drying, the moisture is evaporated, and in making the analysis it is desirable to have the clay dry, so that the analysis generally shows less than one per cent. of moisture or not more than one or two per cent. Some fuller's earths, such as that from Twiggs county, will retain as much as 7 or 8 per cent. of moisture under ordinary conditions of air drying. This is due to the extreme minuteness of the pore spaces of the earth.

The *combined* water is that which is in chemical combination with certain minerals forming the clay, and which is not expelled from the clay except by heating at temperatures above 100° C. The chief sources of the combined water of clays is from the clay base, kaolinite, which contains 13.9 per cent. combined water; limonite, and muscovite mica, contain 14.5 per cent. and 4 to 5 per cent. of water respectively. Bauxite in some of the Georgia clays increases the amount of combined water since it usually contains about 30 per cent. of combined water. A high percentage of combined water indicates that the clay is likely to crack during the early stages of burning.

Loss on Ignition in an analysis includes combined water and carbon dioxide, sulphur and organic matter which may be present.

CHAPTER III

PHYSICAL PROPERTIES AND TESTS OF CLAYS

The physical tests of greatest practical importance to the clay worker are those on plasticity, strength, air shrinkage, burning and fusibility, fineness of grain, slaking and specific gravity. Much of the information given in this and the preceding chapter is of a general character and is familiar to clay technologists, but not to the average clay worker or to those proposing to invest in clay industries and who have not made a scientific study of clays. These chapters are essential to a correct understanding of the tests given in a subsequent part of the report. In writing this part of the report the author as much as possible has given concrete examples and specific allusions to Georgia clays.

Plasticity

Plasticity in clays is the property which they possess, when mixed with water, of being moulded into desired shapes and of retaining their shape after moulding. A number of theories have been advanced in explanation of this valuable property of clays, but clay technologists are not yet agreed upon the cause of it. Likewise, no practical method has been devised of measuring plasticity, and the loose terms used to describe are of little value for comparative purposes. The description of the plasticity of clays is a matter of judgment and will vary with the individual. Plasticity is expressed in such terms as plastic, very plastic, or highly plastic, of medium plasticity, or poorly plastic. Very fine grained, plastic or unctuous clays are described commonly as "fat," while coarse grained, sandy clays, or those lacking in plasticity, are termed "short" or "lean." These terms, however, can at best but convey a hazy idea to the mind, until one has a wide experience with different kinds of clays from widely separated localities and can form a comparison from mental pictures of clays with which he is familiar and which are types of different kinds of plasticity. The soft white clays of Dry Branch may be considered the most highly plastic clays in the State. Some rough estimate of the plasticity of a clay may be obtained by rolling out in the hand a small cylinder of the wet clay ½ or 1 inch in diameter, and noting the degree to which it can be bent without rupture and breaking.

The amount of water required to develop the plasticity of a clay is of much practical importance. The finer the grain and the greater the pore space, the more water is required to develop maximum plasticity. Ordinary brick clays and shales require 15 to 30 per cent. of water; the plastic kaolins of Georgia required 30 to 45 per cent. to develop their maximum plasticity. As an exceptional case the fuller's earth from Attapulgus, Decatur county, requires 90 per cent. of water to develop what poor plasticity it possesses.

Brick clays are not required to possess as much plasticity as some clays used for other wares, and often very sandy or "lean" clays possessing but very little plasticity are used. Where brick are made by the stiff mud process it is not necessary to develop the maximum plasticity of the clay. Fire clays are often very lean or non-plastic and it is necessary to mix a plastic clay with them. Clays used for sewer-pipe, drain tile and roofing tile should have good plasticity, and this is also an essential property of pottery clays. Residual kaolins have only poor plasticity, the sedimentary kaolins, like those of Georgia, and ball clays are highly plastic. Sedimentary clays, with the exception of some metamorphosed shales, are generally more plastic than residual clays.

Plasticity generally bears a relation to air shrinkage and drying qualities of clays—those clays which are most plastic have the highest air shrinkage and are more likely to crack in drying. There are exceptions to this, however. Some Georgia clays approaching fuller's earths in composition were observed to have excessive air shrinkage, yet were only moderately plastic; also, some of the white clays of the Coastal Plain, are observed to be very plastic, but show much lower shrinkage in drying than would be expected.

Strength

The air dried strength of a clay is a very important property in the manufacture of clay products. The water mixed with the clay to develop its plasticity, is expelled by drying, and as the water is evaporated the clay particles are drawn closely together, and the cohesion of the grains gives the clay strength. The strength of some clays is thought to be partly due to an interlocking of the clay grains. The cementing power of colloidal matter (jelly-like or glue-like substance) formed by the action of water upon clay particles will perhaps be found to be the chief cause of strength.

The air dried strength of clays enables them to be handled and to resist shocks before burning, without serious loss from breakage. Clays must also possess air dried strength in order to stand compressive weight without crushing as in the case of brick and sewer-pipe. Strength tests are always given as *tensile* strength, although it might seem more desirable to determine the compressive strength, but the tensile strength, however, will be found to bear a close relation to compressive strength. The strength of a clay also gives some information as to the amount of non-plastic matter which a clay will stand. In the use of some clays for certain purposes it is often necessary to add sand or other non-plastic matter to them.

In the laboratory, tensile strength is determined by measuring, in a machine, the power required for pulling apart air dried briquettes of one inch cross section. In making the tests on the Georgia clays a Fairbanks cement testing machine was used, and the clay to be tested was made into briquettes similar to those used in cement testing. The clays were worked up to their best placticity and carefully moulded to prevent flaws; it was found that the best results were obtained by taking a single piece of clay a little larger than the mould and pressing it firmly into the mould and then trimming off the excess with a sharp spatula. The clays were first air dried in a closed room, special care being taken to prevent too rapid drying and to prevent the cracking and warping which highly plastic clays are subject too. Before breaking in the machine the briquettes were further dried in an air bath at 212° F. Ordinarily only 5 or 6 briquettes of each clay were broken, but when a clay was likely to show great variation in the strength tests, as many as 12 or 15 briquettes were made and broken.

The strength of the Georgia clays tested ranged from 10 pounds (or less) to 320 pounds per square inch. The plastic kaolins and purer fire clays ranged from 10 pounds and less to 150 pounds per square inch; the indurated fire clays or flint clays did not exceed 20 pounds; the bauxite clays of Northwest Georgia were very low and crumbled before their strength could be measured. The brick clays other than shales give from 40 to 320 pounds; the shales of the Paleozoic region, from 20 to 75 pounds. Some of the plastic white clays of the Cretaceous formation showed very high strength; a white clay of high purity from Griswoldville showed a maximum of 135 pounds per square inch. High strength in clays of such purity is very unusual. The shales of Georgia are much lower in strength than those of the Coal Measures of Ohio, Indiana, Iowa, Missouri and other States which are extensively used for brick and other purposes.

Tests on clays from various States have ranged from 0 to 487[1] pounds per square inch. Kaolins are usually low in strength and in using them in the manufacture of porcelain and chinaware, it is necessary to mix ball clays with them to increase their plasticity and strength. The sedimentary kaolins have greater strength than the residual kaolins; in two Georgia kaolins the tensile strength exceeded 100 pounds. Brick clays should have a strength above 50 pounds and preferably 100 pounds. Clays showing less than 50 pounds are used for brick purposes, but the loss encountered from breakage is often serious. The tensile strength of paving-brick clays should be as high or higher than that of common brick; pottery clays should have a strength of 100 pounds, though clays of lower strength are used; sewer-pipe clays should possess a strength above 100 pounds. Clays used in the manufacture of fire clay products will vary according to the particular product. Clays having a strength not exceeding 20 pounds are used, while for some purposes a high strength or bonding power is requisite.

Drying Shrinkage

The diminution in volume of clay, due to the loss by evaporation of the water used in developing plasticity, is termed its air shrinkage or drying shrinkage. The latter term is perhaps preferable, since clay products are not so generally dried in the open air as formerly, but are now dried by artificial heat. In those products where exact and uniform sizes are required the importance of a knowledge of the shrinkage of the clay being used is readily apparent. Even in the case of clays used for common building brick, it is essential that the brick-maker have at least some knowledge of the approximate drying shrinkage of his clay. The shrinkage is very often an index as to the rapidity with which a

1. H. Ries, Clays, Occurrence, Properties and Uses, p. 123.

clay can be dried—a high shrinkage generally denotes a plastic or "tender" clay which is liable to crack and warp if dried rapidly, while low shrinkage indicates a "lean" or coarse sandy clay which can be dried rapidly or placed in the kilns before completely dry, without danger of cracking.

The shrinkage measurements given in this report are linear measurements, made upon small bricklets 4 inches in length. Lines were drawn with the sharp point of a pen knife and measured to 1/100 of an inch, before and after drying and the shrinkage expressed in terms of the wet length. Comparative shrinkage measurements with a standard size brick 8x4¼x2¾ inches, and the small bricklet used in the laboratory tests showed no appreciable differences. The shrinkage measurements obtained in the laboratory will generally be found slightly greater than those obtained in actual practice. In making the shrinkage tests each clay was run through a 40 mesh sieve, worked to its best plasticity and dried at 100°C. in order to obtain results of value for comparison. In the practical working of a clay it may be either finer or coarser grained, smaller percentage of water used in mixing and worked to greater density by machine moulding, all of which would produce variations in shrinkage.

The shrinkage of the Georgia clays tested ranged from less than 1 per cent. in very hard flint clays and coarse sandy brick clays to 17 per cent. in a very fine grained, minutely porous fuller's earth. If the shrinkage is above 5 or 6 per cent. it may be considered high, if above 10 or 12 per cent. it is excessive. The Georgia plastic kaolins and fire clays of the Coastal Plain ranged approximately from 3 to 9 per cent.; the bauxite clays showed low shrinkage, 2 to 6 per cent.; the brick clays, other than shales, showed from 1 to 17 per cent.; the shales of the Paleozoic area gave from 1 to 7 per cent.

It often becomes necessary to reduce the shrinkage of a clay in order to successfully utilize it in the manufacture of clay products. The most common anti-shrinkage agent is sand or sandy loam. Coarse sand is more effective than fine sand, and when the sand is extremely fine, no appreciable lessening of the shrinkage takes place unless a very high percentage is added. The addition of sand or other non-plastic material to a clay, reduces its plasticity and strength, and makes the burned product more porous, so that the amount of non-plastic material which can be safely added will be determined by the peculiar properties of the clay.

Burning Tests

In making burning tests on clay, tests and observations should be made for fusibility and degree of fusion at various temperatures, shrinkage at different temperatures, color under various conditions, and other phenomena which clays might exhibit, as swelling, warping, etc., which it would be necessary to know in forming an opinion as to the value and uses of a clay.

In making tests on Georgia clays a small gas-fired laboratory kiln was used for low temperatures and the Deville furnace, fired with coke, was used for determining the fusibility of refractory and semi-refractory clays. For testing, small bricklets 3½x1½x½ inches and 3½x1½x1 inches were used. It is to be regretted that large samples could not be burned and that the tests could not be made under conditions more closely approximating those in actual practice, but neither the time nor equipment was available.

For obtaining temperatures, the series of pyrometric cones, manufactured by Prof. Edward Orton, Jr., Columbus, Ohio, were used. The following is a table giving the approximate temperatures of fusion of the cones in Centigrade and Fahrenheit:

	FUSION POINT			FUSION POINT	
No. of Cone.	*Cent.*	*Fahr.*	*No. of Cone.*	*Cent.*	*Fahr.*
022	590	1094	8	1290	2354
021	620	1148	9	1310	2390
020	650	1202	10	1330	2426
019	680	1256	11	1350	2462
018	710	1310	12	1370	2498
017	740	1364	13	1390	2534
016	770	1418	14	1410	2570
015	800	1472	15	1430	2606
014	830	1526	16	1450	2642
013	860	1580	17	1470	2678
012	890	1634	18	1490	2714
011	920	1688	19	1510	2750
010	950	1742	20	1530	2786
09	970	1778	21	1550	2822
08	990	1814	22	1570	2858
07	1010	1850	23	1590	2894
06	1030	1886	24	1610	2930
05	1050	1922	25	1630	2966
04	1070	1958	26	1650	3002
03	1090	1994	27	1670	3038
02	1110	2030	28	1690	3074
01	1130	2066	29	1710	3110
1	1150	2102	30	1730	3146
2	1170	2138	31	1750	3182
3	1190	2174	32	1770	3218
4	1210	2210	33	1790	3254
5	1230	2246	34	1810	3290
6	1250	2282	35	1830	3326
7	1270	2318	36	1850	3362

FUSIBILITY.—During the early stages of the burning of a clay, the hygroscopic water or moisture and the combined water and volatile elements, as sulphur dioxide, carbon dioxide, and organic and carbonaceous matter are driven off. This takes place at a temperature below 1000° C. After the volatile elements are driven off the clay is in a more or less porous condition and no shrinkage has taken place, but on the contrary there may be a slight expansion. At low temperatures, a fusion or melting of some of the more fusible constituents of the clay takes place; this fusion of the mass gradually increases until it becomes glassy or vitrified and only coarse quartz grains can be recognized. Beyond the vitrification stage, with increase of temperature, the clay becomes viscous and flows or is completely melted. In the manufacture of clay wares, it may be necessary to burn the clay only to the point at which there is a partial fusion, or merely a sufficient fusion to bind the mass together while the greater part of the mineral constituents are unfused, as in the case of soft burned brick; or for other wares it may be necessary to effect sufficient fusion to make the product steel hard, or to bring the mass to such a state that it is more or less glassy and the mineral constituents have lost their identity, or to vitrification.

The fusion of a clay, or the temperatures required to bring the clay into such a condition as the use of the product made from it demands, depends upon a number of variable factors, as the mineralogical and chemical composition, texture or size of the grains composing the clay, conditions of firing and rate of firing. In general those clays having high percentages of fluxes as shown by the ultimate analysis will have low fusing points, as for example we know that a brick clay will fuse at a lower temperature than a kaolin or fire clay. However, an opinion as to the burning properties of a clay based upon the ultimate analysis alone, is liable to grave error, since the analysis gives no indication of the texture of the clay and the manner in which the oxides are combined, or its mineralogical composition and its homogeneity, or the distribution of compounds in the clay, all of which affect its fusion. It has been observed in numerous instances that clays of nearly the same chemical composition may have widely separated fusing points.

In regard to effect of conditions of burning it is also believed that fusion is brought about at a lower temperature in an oxidizing atmosphere than in a reducing one. It has likewise been observed that fusion can be effected at a lower temperature by long continued slow firing, than by very rapid heating.

The points at which clays will completely fuse or melt ranges from approximately cone 07 in the case of very impure shales to cone 36 in the case of kaolins, while it is probable that some clays containing a percentage of bauxite will exceed cone 36.

It is only in the case of fire clays that it is essential to test for high refractoriness and the useful properties of burned clay products is developed at vitrification and the lower stages of fusion. The following is a table given by H. Ries[1] of the approximate cones used in the burning of various clay products in the United States:

	Cones
Common brick	012—01
Hard-burned, common brick	1—2
Buff front brick	5—9
Hollow blocks and fireproofing	03—1
Terra cotta	02—7
Conduits	7—8
White earthenware	8—9
Fire bricks	5—18
Porcelain	11—13
Red earthenware	010—05
Stoneware	6—8

In the laboratory testing, the clays were burned at temperatures approximating those used in practice and the effect at the different temperatures noted. Thus a brick clay might be burned at cones 07, 05, 01, 2, and 5, and at these different cones would be observed to change from a soft salmon at cone 07 to bright red and steel hard at cone 01, and complete vitrification at cone 2, and viscosity at cone 5.

FIRE SHRINKAGE.—After the combined water and volatile elements in a clay are driven off, it is left more or less porous, in addition to its porosity caused by the grains composing the clay, not fitting closely together. As fusion begins, the pore spaces are closed up by the melting of the constituent grains of the clay, thereby causing a gradual shrinkage in volume, until the point of vitrification is reached, when the mass becomes homogeneous and non-porous. Beyond vitrification there may be expansion due to the volatilization of the clay.

1. Clays, Occurrence, Properties and Uses, p. 153.

The amount of fire shrinkage shown by clays ranges from less than one per cent., in very coarse sandy brick clays, to as high as 20 per cent. in a very porous fine-grained clay. High shrinkage is usually accompanied by warping or cracking. Shrinkage above six or seven per cent. may be considered high. Kaolins and the purer clays generally show the highest fire shrinkage, though some impure clays, in the nature of fuller's earth, in Georgia, showed shrinkage exceeding 20 per cent.

In the manufacture of encaustic tile, electrical porcelain or any other ware where exact and uniform sizes are required, the control of fire shrinkage becomes an important problem. Sand and grog (ground brick, saggers, etc.) are mixed with a clay to reduce fire shrinkage.

In measuring the fire shrinkage of the Georgia clays the dried bricklet was measured to 1/100 inch before and after burning and the fire shrinkage expressed in terms of the length of the dried bricklet. Since shrinkage begins at incipient fusion and increases to vitrification, the bricklets are drawn from the kiln at different temperatures in order to determine the amount of shrinkage and the rate of shrinkage.

Color in Burning.—Since color plays such an important role in the value of clay products, observations on color are an essential part of clay testing. Iron compounds both in the burned and unburned clay are the chief coloring agents, but neither the shade nor depth of color in the raw clay nor the amount of iron shown by analysis is any sure index to the burned color. In general one may be reasonably certain that a clay which is yellow, red or brown in nature will burn to some shade of red under oxidizing conditions in the kiln and at temperatures approaching vitrification, also that a clay containing more than three or four per cent. of iron oxide; Fe_2O_3, in the analysis, will burn some shade of red providing there is no excess of lime to neutralize its coloring effect.

The ultimate analysis gives us neither the form in which the iron exists nor its distribution.

Temperature in burning plays an important part in producing color effects. Generally the depth of color increases with the temperature. For example, some white clays may show no trace of color at cone 4, but develop a decided cream color at cone 9. It is most often in the examination of white clays which are likely to prove suitable for the higher grades of clay wares, that predictions of the burned color are based upon the amount of iron shown by the chemical analysis, but the errors are often as serious as in other clays.

The kiln conditions likewise affect the color, whether oxidizing or reducing. The iron is converted into ferric form under oxidizing conditions and in this form its red color effect is stronger, while reducing gases tend to convert a red color into a bluish or bluish-black.

Texture

The size of the grains composing clay varies from that of small pebbles to particles so extremely minute as to remain in suspension in water for several days and be beyond the measurement of the highest power microscopes. The coarseness or fineness of grain in clays plays an important part in their plasticity, strength, fusibility, shrinkage and color. The clay grains may be of a comparatively uniform size or there may be a variation in sizes. In examination of the plastic kaolins of the Fall Line of Georgia, it was observed that in some cases above 95 per cent. of the clay passed a 200 mesh sieve, and upon being agitated in a large beaker of water a sufficient amount of the clay remained in suspension to make the water milky for a period of a week and over.

Slaking

The slaking of clays is the property they have, when dry, of crumbling and disintegrating into pulverulent mass when placed in an excess of water. Slaking has some practical bearing upon the utilization of clays. The "weathering" or slaking of shales increases their plasticity and facilitates tempering, and those clays used in the manufacture of paper as a filler should slake readily, since clays that become finely pulverulent have greater plasticity and spread more evenly, while those which are lumpy leave "clay spots" on the paper. Thus the property of slaking may be of especial interest to clay miners in Georgia, since large deposits of paper clays exist and are mined and sold in extensive quantities. Slaking also has a bearing on the washing of a clay, since washing is facilitated by the ready disintegration of the clay.

In slaking, the water first fills the pore spaces of the clay; then the particles of clay are entirely surrounded by a film of water, being separated from each other by thickness of the film thus causing an increase in the volume of the clay. When an excess of water is added, the clay grains become so far separated from each other that the clay mass crumbles. The process seems to be entirely physical and it is doubtful if any disintegration is due to chemical action, as in the slaking of quick lime. Thus it may be perceived that a clay which has undergone a considerable degree of consolidation, as shales, or those which are cemented by lime, iron or silica would slake very slowly. Soft kaolins slake completely within a few minutes, while some shales and very hard flint clays slake with extreme slowness or not at all.

In order to make comparative tests on the slaking of clays, one inch cubes were dried in air bath at 212° C. and were immersed in 250 CC. of water at 25° C. and the time noted for plete disintegration. The degree and time of slaking depend upon the mass of the clay, freedom from moisture, the temperature of the water and the purity of the water. The rapidity of slaking increases directly as the temperature of the water up to the boiling point. Any substance which increases the density of the water, retards the slaking of the clay—alum and common salt placed in the water produced a very marked retardation. Tests are of no value for comparison unless the samples are free from moisture, as the presence of a small amount before immersion retards the slaking. When the clay is perfectly dry, and is immersed in water there is a hissing sound, and the expulsion of the air frequently takes place with such force that drops of water are blown from the vessel containing the water.

The following are comparative slaking tests made upon Georgia clays:

SLAKING TEST

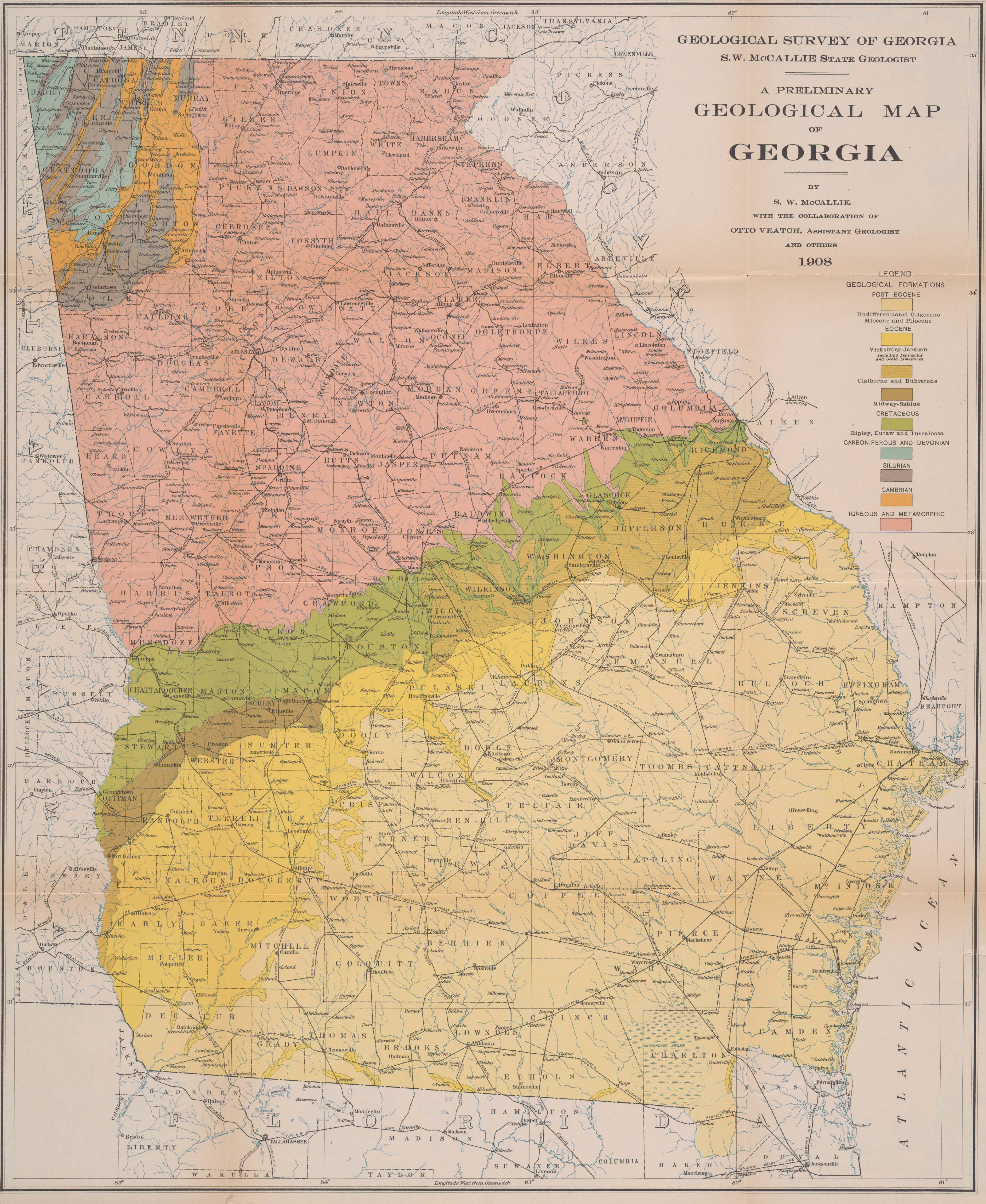
	Time	*Degree of slaking*
Paper clay, Georgia Kaolin Co.	6 min.	fine powder
Paper clay, American Clay Co.	3 min.	fine powder
Paper clay, Atlanta Mining & Clay Co.	5 min.	fine powder
Paper clay, Albion Kaolin Co.	4 min.	fine powder
Flint clay, Gibson	....	no slaking
Paper clay, Butler	4 min.	pulverulent
Plastic white clay, Gibson	5 min.	flaky
White clay, Perry	2½ min.	lumpy
Fire clay, Copperas Bluff	2½ min.	coarse granules
Fire clay, Carr's Station	7 min.	flaky
White, plastic clay, J. T. Hatfield	7 min.	granular
White clay, Rico mine	4 min.	complete
Pottery clay, I. Mandle	10 min.	slightly mealy
Shale, Chatsworth	4 days	very slight disintegration
Bauxite clay, Hampton mine, Cave Spring	4 min.	coarse, angular
Fuller's earth, Twiggs county	20 min.	very fine flakes
White clay, Van Buren	6 min.	fine powder
White clay, Carswell, McIntyre	3½ min.	slightly granular
White clay, Chalker	5 min.	coarse granules
White clay, Byron	5 min.	coarse flakes
Terra cotta clay, Aragon		splits into coarse flakes, but does not show complete disintegration.
Shale, Calhoun		only very slight disintegration

The specific gravities of the following clays were determined by the pycnometer[1] method:

1. The determinations were made by Dr. Edgar Everhart, chemist of the Geological Survey of Georgia.

Specific Gravity

Washed kaolin, Griswoldville	2.62
Plastic kaolin, Griswoldville	2.39
Bauxitic kaolin, Rome	2.45
Bauxitic kaolin, Rome	2.34
Fuller's earth, Attapulgus	2.21
Fuller's earth, Bibb county	2.17
Plastic kaolin, Atlanta Mining & Clay Co	2.61
Plastic kaolin, Georgia Kaolin Co	2.61
Plastic kaolin, McIntyre	2.48
Plastic kaolin, I. Mandle & Co	2.52
Stained kaolin, N. T. Carswell	2.64
Flint clay, Gibson	2.43
Plastic kaolin, Gibson	2.69
Bauxitic kaolin, Hermitage	2.45
Roofing-tile clay, Ludowici	2.50
Fire clay, Fort Valley	2.59
Brick clay, Telfair county	2.60
Brick and pottery clay, Turin, Chas. T. Moses	2.50
Fire and terra cotta clay, Aragon	2.62
Bauxitic kaolin, Cave Spring	2.54


GEOLOGICAL SURVEY OF GEORGIA
S. W. McCALLIE STATE GEOLOGIST
A PRELIMINARY
GEOLOGICAL MAP
OF
GEORGIA
BY
S. W. McCALLIE
WITH THE COLLABORATION OF
OTTO VEATCH, ASSISTANT GEOLOGIST
AND OTHERS
1908
LEGEND
GEOLOGICAL FORMATIONS
POST EOCENE
Undifferentiated Oligocene Miocene and Pliocene
EOCENE
Vicksburg-Jackson
Including Peninsular and Ocala Limestones
Claiborne and Buhrstone
Midway-Sabine
CRETACEOUS
Ripley, Eutaw and Tuscaloosa
CARBONIFEROUS AND DEVONIAN
SILURIAN
CAMBRIAN
IGNEOUS AND METAMORPHIC
Longitude West from Greenwich
ATLANTIC OCEAN
FLORIDA
ALABAMA
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA

CHAPTER IV

THE GEOLOGICAL DISTRIBUTION OF THE CLAYS OF GEORGIA

The clays of Georgia of commercial value have a wide geological distribution, ranging from the pre-Cambrian igneous and metamorphic rocks to the alluvial deposits of the Pleistocene. The following is a table of the successive geological formations found in the State.

TABLE OF GEOLOGICAL FORMATIONS

Pleistocene	Columbia	
Tertiary	Pliocene	Lafayette (?)
		Altamaha
	Miocene	
	Oligocene	Chattahoochee group (undifferentiated)
	Eocene	Vicksburg-Jackson
		Claiborne
		Midway-Sabine
Cretaceous	Upper Cretaceous	Ripley
		Eutaw
	Lower Cretaceous	(Tuscaloosa)
Carboniferous	Walden sandstone	
	Lookout sandstone	
	Bangor limestone	
	Oxmoor sandstone	
	Floyd shales	
	Fort Payne chert	
Devonian	Chattanooga shale	
	Frog Mountain sandstone	
	Armuchee chert	

Silurian	Rockwood formation Rockmart slate Chickamauga limestone Knox dolomite (upper part)
Cambrian	Knox dolomite (lower part) Conasauga shale Rome formation Beaver limestone Weisner quartzite
Pre-Cambrian	Igneous and metamorphic rocks

THE PLEISTOCENE

The Columbia[1] formation has two distinct phases in Georgia, an alluvial or "second bottom" phase, and an inter-stream or sand-hill phase. The Columbia alluvium is typically developed in the upper part of the Coastal Plain along the larger streams, the Chattahoochee, Flint, Ocmulgee, Oconee and Savannah rivers. This alluvium was deposited during the late inundation stage when the large streams of the Coastal Plain were converted into estuaries and their upper courses flooded. The formation is confined to the courses of the large streams, and in the lower part of the Coastal Plain may merge into the earlier *sand* phase of the Columbia.

Good exposures of the "second-bottom" alluvium may be seen at Columbus, Macon and Augusta on the Fall Line. It consists mainly of irregularly stratified, loamy sand and small gravel, with pockets or lenses of plastic and sandy clays. It probably does not exceed 40 feet in thickness at any point. The clay lenses do not exceed 15 or 20 feet in thickness and the average is 6 or 8 feet along the Fall Line. The general section in the clay pits examined at Columbus, Macon and Augusta, is in descending order:

1. The name Columbia was applied by W. J. McGee. 12th Ann. U. S. G. S., part I.

1	Loam and sand	1 to 2 feet
2	Yellow or brownish clay, usually with black, iron oxide accretions	———
3	Bluish, stiff, plastic clay	———
4	Fine sand and gravel	———

The sand is usually yellow or red from iron oxide, but may be in places almost pure white.

The alluvium was mainly derived from the crytalline rocks of the Piedmont region, but the character of the material along the lower courses is affected to some extent by the Cretaceous and Tertiary marls and limestones over which the streams flow.

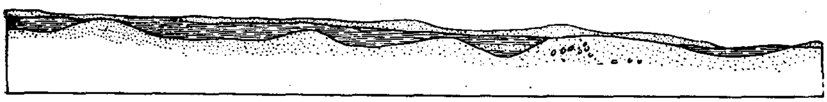


Fig. 3.—Longitudinal Section of an Alluvial Plain bordering a Coastal Plain River. The Horizontal Lines represent Clay; the Dots, Sand.

The clay of the Columbia alluvium is plastic, possesses good strength and is red burning. It is generally non-calcareous or contains only a very small percentage of lime; iron oxide is the principal fluxing impurity. It is being successfully used for common and repressed brick, sewer-pipe, drain-tile and roofing-tile.

Localities.—The following are the principal localities where the Columbia alluvium may be seen and is being utilized: Columbus, banks of the Chattahoochee River, and G. O. Berry and Shepherd Brothers brick yards; Macon, used extensively for common brick, sewer-pipe and drain-tile; Milledgeville, J. M. McMillan; Augusta, used extensively for common brick; Ludowici, used for roofing-tile; Lumber City, Mount Vernon, Omaha, Georgetown, Bainbridge. There are extensive undeveloped deposits in the "second bottoms" of the large rivers of the Coastal Plain. The alluvial belt along these large rivers varies from one-half mile to five miles in width.

Columbia Sand

The Columbia sand is older than the alluvium above described. In distribution it forms a thin mantle over the greater part of the entire Coastal Plain and laps over, in places, into the Crystalline area. It consists of gray or brown, fine sand, containing rarely small pebbles, and is loose and unconsolidated, and seldom shows lines of stratification. In origin it is a shallow water or beach deposit; on account of its fine and loose texture it has been shifted by winds and shows in places a wind structure. The sands consists mainly of quartz, stained by iron oxide, and small amounts of mica and other minerals derived from igneous rocks. It varies in thickness from 0 to 50 or 60 feet, with the average over the entire Coastal Plain not exceeding 10 feet, and probably much less. The Columbia sand overlies unconformably all of the Cretaceous and Tertiary formations, in places entirely concealing them. The sand-hill or Fall Line phase of the formation is typically represented in the vicinity of Augusta and near Butler and Howard in Taylor county. In the southern and southeastern parts of the Coastal Plain, it generally forms a flat featureless plain, but it is often heaped up into hills or dunes along the stream courses. The formation is prominent as a loose, gray, surface sand in the counties of Charlton, Camden, Chatham, Effingham and other counties in southeastern Georgia. It is not clay bearing, and hence is of but little interest to the clay worker, except in its relations to other clay bearing formations.

In Chatham and Glynn counties small deposits of plastic clays were observed, evidently of Pleistocene age,—probably later than the Columbia sand. Recent oyster shells were observed in some of these deposits, which show them to be of marine origin. These deposits are usually small in area, and as far as explored are only a few feet in thickness, though in an exceptional case near Savannah, 22 feet of clay was found by boring. These marine, Pleistocene deposits in the coast counties may be of value for common brick purposes. The only locality where they are at present used, is at Pooler, nine miles west of Savannah.

TERTIARY FORMATIONS

Lafayette

The Lafayette formation has not been closely discriminated in Georgia, and the exact status of the term *Lafayette* in this State has not been firmly established. No attempt has heretofore been made to differentiate the formation from other formations of the Coastal Plain and map it in detail. W J McGee[1] studied the Lafayette in Georgia and regarded it as an extensive, superficial formation overlying the whole Coastal Plain, and in a general map of southeastern United States gives its distribution in Georgia. It is believed that heretofore certain red sands and gravel of the Eocene and Cretaceous formations, closely similar, have been confused with the Lafayette, and that the Lafayette, as described by McGee, and the Altamaha formations are equivalent in the Southern part of the State. The red loamy sand and coarse gravel capping the hills at Columbus, Macon and Augusta, and described by McGee[2] as Lafayette, can not be recognized on the divides between the Chattahoochee, Flint, Ocmulgee, Oconee and Savannah rivers, and do not overlie the intervening country between the above cities. The deposits flanking the large streams, may be a later estuarine phase of the extensive Altamaha formation. The writer proposes that the term Lafayette be retained for these deposits. The formation contains no fossil criteria for determining its age; it is younger

1. U. S. Geol. Surv. 12th Ann. part I.
2. U. S. Geol. Surv. 12th Ann. part I.

than the Altamaha and is perhaps Pleistocene rather than Tertiary.

The Lafayette capping the second terraces and mantling the higher hills at Augusta, Macon and Columbus on the Fall Line, is a bright red, loamy sand, crossbedded and rudely stratified, and coarse quartz and quartzite well-rounded pebbles, which may attain a diameter of 4 or 5 inches. The formation rests unconformably upon the lower Cretaceous or Tuscaloosa strata, from which it may be readily distinguished by its greater coarseness and higher iron content. The thickness of the formation has not been accurately determined, but it is not great. The formation as here described, contains no commercially important clay beds. It may overlie the valuable clays of the Cretaceous formations and should be distinguished from that formation.

Altamaha Formation

The Altamaha formation, as here described, undoubtedly includes much that has heretofore been classed as Lafayette in South Georgia. The Altamaha formation as studied by R. H. Loughridge[1] and W. H. Dall[2] was classed as Miocene; but later investigation by the writer, Prof. S. W. McCallie, and others, would tend to place it in the Pliocene. The Altamaha formation is the most extensive in the State, covering as it does about 3/5 of the entire Coastal Plain. From the Atlantic coast and the Florida boundary line, the formation extends northward into Burke county, thence going in a southwestward course, its northern extent is marked by the towns of Tennille, Dublin, Hawkinsville and Vienna to Flint River. West of Flint River no formation has been identified with certainty as the Altamaha; in Decatur county in the extreme southwest corner of the State there is a probable occurrence. The areal

1. Tenth Census, Georgia.
2. U. S. G. S. Bulletin 84, p. 81.

extent of the formation is approximately represented by the post Eocene color on the geological map accompanying this report. It is possible that in future work, the extensive area above bounded, will be further differentiated.

The formation is of much importance on account of its contained clay beds. Throughout much of southern Georgia, it is the only geological formation present, and furnishes the only source of clay for brick purposes. The Altamaha as a whole, is a great mantle of sand, gravel and clay which overlies nearly all of the earlier Tertiary deposits. As a whole, it is homogenous and consists of yellow and red sand and both massive and stratified layers of gritty clay, with local areas of indurated grits or sandstone and clay. It attains a maximum thickness of 350 feet or more. The surface aspect which is peculiarly characteristic throughout the terrane, is a mottled or "calico" effect, which is due to the unequal weathering and oxidation of iron minerals. The formation is a marine or estuarine deposit and the material composing it was derived from the crystalline rocks of the Piedmont region.

The sand of the formation is usually coarse quartz sand, red and yellow or orange in color and has occasionally a brownish tint; it is always more or less argillaceous, and contains layers of small quartz and quartzite pebbles. The grit or sandstone feature is a gray or greenish, aluminous sandstone, more or less mottled and stained by iron oxide. The percentage of clay in the indurated rock varies from 5 to 10 per cent. to such a high percentage, that the rock is an indurated clay rather than a sandstone. The rock may be very hard and even glassy and quartzitic in appearance, but is generally soft and friable.

The clay of the Altamaha formation is fairly uniform in texture and composition throughout the area. It is greenish or drab in color, very fine grained and plastic and always more or less sandy. It occurs as irregular pockets or lenses and in thin layers or leaves, never persisting as individual beds over any large area. A tolerably characteristic appearance throughout is a greenish clay full of coarse angular quartz pebbles and subangular, decomposed feldspar. The clays may be locally indurated, and then are lacking wholly in plasticity. The clays are generally red burning, but at a few points white clays have been noted which contain only a small percentage of iron oxide. The clays are interstratified with friable sand and may occur as thin layers or leaves, not more than an inch thick. The strata lie almost horizontal and are in no place disturbed by faulting or folding. As above mentioned, there is no individual clay bed which persists over a large area, but the clay occurs in pockets of irregular thickness which may grade into or be replaced by sand and sandstone. The formation is predominately a sand formation, and it is not at every point that sufficient clay occurs near the surface for the establishment of brick plants.

The clay does not vary greatly in chemical composition and physical properties throughout the area. Iron oxide is the chief fluxing impurity, and it is low in lime, magnesia and the alkalies. The clay is never carbonaceous and is free from pyrite and lime concretions, but frequently contains small flattened nodules of silica. It is generally necessary to mix sand with it to improve its working qualities and counteract excessive air shrinkage and prevent cracking in drying. It possesses good air-dried strength, attaining as much as 275 pounds per square inch. The burned product is usually porous on account of the high sand content. The clay does not give promise of being suitable for any other products than common building brick.

Localities.—The clay of the Altamaha has been utilized at only a few localities. There are many undeveloped deposits

FIG. 1.—SAND PIT, COLUMBIA SAND, HOWARD, GEORGIA.

FIG. 2.—SAND STREAM, CRETACEOUS, NORTHERN PART OF MARION COUNTY.

which could be used to supply a local demand for common brick. The following are points where this clay is being utilized: Waynesville, Waynesville Brick Company; Odessa, common brick; Douglas, common brick. The clay occurs in abundance convenient to railways in Decatur and Grady counties; both soft and indurated clays of the formation are prominent in Laurens county south of Dublin; good exposures of the sand and clay of the formation may be seen in the cuts of the Southern Railway in Telfair and Dodge counties; also in the cuts of the Seaboard Air Line Railroad in Toombs, Montgomery, Dodge and Wilcox counties, and along the Atlantic Coast Line Railroad in Worth, Tift and Coffee counties. There are also numerous exposures in the railroad cuts in Emanuel county.

Miocene

The Miocene in Georgia has not been closely studied and has not been differentiated from other Tertiary formations. It has been recognized in the bluffs of the Altamaha River at Doctortown where it is overlain by 30 feet of sand belonging to the Altamaha formation. It probably has a limited occurrence along the Atlantic coast. Exposures are rare, as it is largely concealed by Pliocene and Pleistocene sands. It is not known to contain any valuable clays.

Oligocene

The Oligocene in Georgia is of wide areal distribution, though but little detailed information about its character and extent has been published.

Rocks of the Chattahoochee group are well exposed in the gorge northwest of Faceville, in Decatur county, and in the sink at Forest Falls, Grady county. The Chattahoochee group

1. Science, N. S., XII, pp. 873-75, Dec. 7, 1900.

was formerly considered Miocene, but by the labors of Dr. W. H. Dall, the nomenclature has been revised and Oligocene substituted for the "old Miocene," since he was able to correlate the fauna of the Miocene with the Antillean Oligocene. By the work of Dr. T. W. Vaughan[1] of the U. S. Geological Survey in Decatur county, Georgia, the lower Chattahoochee, has been correlated with the Oligocene of the island of Antigua. The formation consists mainly of limestone and marl.

Fossils collected by the writer from a shell marl and sandy clay near Traders Hill in Charlton county, were submitted to Dr. W. H. Dall, who regarded the formation here as probable Oligocene.

The section exposed in the bank of the St. Marys' River about three miles above Traders Hill, is as follows:

1	Greenish and drab massive sticky clay............	6	feet
2	White plastic laminated clay.....................	2	"
3	Clay marl full of shells.........................	2	"
4	Soft, argillaceous limestone.....................	1	"
5	Greenish and white plastic clay with a few fossils, to water's edge.........................	3	"

On the Withlacoochee River, 13 miles south of Valdosta, there are exposures of bluish and greenish stiff clay containing flint fragments and silicified corals, and beds of siliceous limestone. From fossile collected by Prof. S. W. McCallie and submitted to Dr. T. W. Vaughan, the formation here has been referred to the Oligocene.

The fuller's earth formation of Decatur county is considered as being of Upper Oligocene age and the equivalent of the Alum Bluff beds[1].

The Oligocene as far as examined by the writer, does not contain any valuable clay beds. The fuller's earth of Decatur county, while excellent as a fuller's earth, is not of value for clay products.

1. T. W. Vaughan, U. S. G. S. Bulletin 213, p. 392.

Vicksburg-Jackson

The Vicksburg-Jackson formation underlies a large area in the western part of the Coastal Plain of Georgia. It is a limestone, sand and clay formation. The type localities of the formation are at Vicksburg and Jackson in Mississippi, from whence it has been traced eastward into Alabama and Georgia. It is the equivalent of the St. Stephens formation of Alabama. The formation has not been regarded as divisible upon paleontological grounds.

In Georgia, the Vicksburg-Jackson underlies the greater part or all of Pulaski, Sumter, Lee, Randolph, Dougherty, Early, Terrell, Calhoun, Miller and Baker counties. The lower part of the formation as exposed at Rich Hill in Crawford county, and south of Perry in Houston county, is a soft or "rotten" limestone, and thinly bedded clays and some glauconitic clay and sand; the upper part consists of flinty limestone and semi-consolidated sand, bearing some clay.

The following is a section at Mossy Hill, three miles southeast of Perry, Houston county. The section is in descending order:

1	Flint fragments in red, clayey soil	10	feet
2	Soft, fossiliferous limestone	4	"
3	Laminated clay or clay-marl	12	"
4	Soft limestone	4	"
5	Laminated, silty clay, containing thin, calcareous layers and calcite nodules	15	"
6	Ash-colored marl, very fossiliferous	5	"
7	Soft limestone	4	"
8	Soft, yellowish "rotten" limestone or marl	6	"
9	Hard, compact limestone	6	"
10	Massive bedded, soft, gray limestone	15	"
11	Greenish, fine grained, laminated clay	—	"

Fossils[1] from this locality have been identified as Jacksonian.

The upper Vicksburg limestone is white or gray in color

1. Fossils collected by Prof. S. W. McCallie and identified by T. W. Vaughan. See Geological Survey of Georgia, Bulletin No. 15, Underground Waters of Georgia, p. 352.

and generally flinty, the flint having replaced the limestone. At some localities the limestone, however, is almost pure calcium carbonate and has been used in the manufacture of lime. Overlying the limestone there is a bright red or orange sand which is conspicuous in Sumter, Lee, Randolph, Terrell. Dougherty and other counties. The bright red color is a surface phenomenon, and at depths the sand is lighter in color. The sand may contain clay layers, but these do not give promise of commercial value so far as observed. This sand is of variable thickness; from data from well records, it may reach a thickness of 100 feet or more. The red sand of this region has been regarded as Lafayette in previous literature, but the writer ventures the opinion that it will be found to be Eocene in age. It bears no close resemblance to the Altamaha sands and clays and can not be correllated with that formation on lithological grounds. It has been observed containing flint fragments of the Vicksburg limestone, which have resulted from the carrying away in solution of the limestone in which they were contained and much of the red clayey sand overlying the Vicksburg formation is doubtless residual. No unconformity between the sand and the underlying limestone has been observed.

Claiborne

The Claiborne group is a marine deposit which consists of laminated clays, sand, limestone, and marl. The formation occupies a small area in the northeastern part of the Coastal Plain, east of the Ocmulgee River. It underlies parts of Twiggs, Jones, Wilkinson, Washington, Glascock, Jefferson, McDuffie, Columbia, Burke and Richmond counties. It overlies the Tuscaloosa clays and sands and laps over in a few places into the Crystalline area. The formation itself contains some commercially valuable clays and is of further interest on account of its relations to much of the valuable white clays of the Cretaceous—directly overlying these clays and constituting their overburden.

A small, narrow area of the Claiborne also occurs along the Chattahoochee River in Early county. It consists of sand, sandy limestone, quartzite and some calcareous clays, and reaches a thickness of 250 feet.

The Claiborne in the northeastern part of the Coastal Plain is, in its lower part, a laminated clay or fuller's earth and limestone, while the upper part is a sand formation. The group will probably be found divisible upon lithological character, if not upon paleontological grounds. From a well record at Louisville, in Jefferson county, the formation reaches a total thickness of 350 feet. Its maximum at any point will hardly exceed 400 or 500 feet.

The fuller's earth phase of the formation consists of laminated or thinly bedded clays, which may reach a thickness of 100 feet or more. These clays are generally gray, greenish or drab in color, soft, and contain frequently calcareous nodular layers. The clay is distinguished by its low specific gravity and peculiar physical properties. It is soft and unctuous, jointed, and breaks with a smooth, conchoidal fracture. Thin layers are often observed which are tough and waxy and highly colored red, yellow and purple by iron oxides.

It may occur as thin leaves or laminæ only a half inch or an inch thick, alternately stratified with equally thin layers of sand. It frequently contains calcareous nodules and may be largely replaced by vari-colored sands. A good exposure of the formation may be seen on the Marion public road, 10 miles south of Macon on the old Tharpe place, where there is 80 feet of fuller's earth and fuller's earth-like clay, overlain by 50 feet of red sand; and also on the Macon, Dublin and Savannah Railroad, near Pike's Peak in Twiggs county, where it is seen unconformably overlain by red sand. The fuller's earth formation is continuous from Bibb and Twiggs counties northeastward into Richmond and Columbia counties. A small area of lignitic clay occurs in Columbia county, and thin-bedded, shale-like aluminous sandstone was observed in Jefferson and Glascock counties lying in contact with the Cretaceous sediments.

Limestone and marl appear at a number of localities, though they form only a small percentage of the whole formation. Thin layers of soft limstone frequently occur in the fuller's earth clay, but are not of large extent areally. The greatest thickness of Claiborne limestone and marl occurs at Shell Bluff on the Savannah River, Burke county. The bluff is capped with 15 to 20 feet of red unconsolidated sand, beneath which there is 100 feet of gray and yellow sandy marl of varying degrees of hardness, containing shell beds. Near the water's edge there is 12 feet of large oyster shells, *Ostrea Georgiana,* unconsolidated.

The sand of the Claiborne is generally highly ferruginous and at the surface a bright red in color, and is full of small black accretions of iron oxide, but where there are unweathered exposures the sand is yellow, purplish and white. It is unconsolidated except in a few localities where it contains pebble beds which have been cemented by iron oxide. It contains thin limonite crusts, and may also contain thin clay leaves or laminæ and small patches of fossiliferous quartzite. In the Dry Branch region and at other localities Claiborne sand lies directly above the white clay beds of the Tuscaloosa, and constitutes their overburden. The sand is conspicuous at the surface throughout the Caiborne terrane, forming the upper member of the Claiborne formation, and has been mistaken for the Lafayette. It is unfossiliferous, except for the patches of quartzite which it contains and occasional fossil-bearing clay layers.

Properties of the Clays.—The clays of the fuller's earth phase of the Claiborne are red or buff burning, have only moderate plasticity, and show a tendency to crack badly in drying and burning. The samples tested showed high air shrinkage, from 10 to 18 per cent., and required a high percentage of water for mixing. Their air dried tensile strength is high, giving as much as 300 pounds per square inch. Used alone, they do not give much promise of value for clay products, but may be used with other clays. The fuller's earth is being mined and placed upon the market at Pike's Peak by the Continental Clay Company, and the material offers possibilities of an extensive use for this purpose.

LOCALITIES.—Clay of the Claiborne formation is being utilized at the following localities: 1. Campania, Georgia Vitrified Brick and Clay Co.; 2. Stevens Pottery, mixed with fire clay. A number of localities of undeveloped deposits are described in detail in subsequent pages of this report. The clays of the Claiborne directly overlie the white clays of the Tuscaloosa at the mines at Dry Branch; they are prominent in Wilkinson county south of Gordon; other localities where they are exposed are: Roberts Station, Jones county; Carswell property, three miles east of McIntyre; and at Grovetown, Columbia county.

MIDWAY FORMATION

The Midway formation is a marine deposit of sands, clays and limestones of Lower Eocene age. The formation is capable of several subdivisions, but these have never been mapped, and it is here considered as a unit. The Midway is a narrow belt of rocks, 10 to 15 miles in width, extending from Fort Gaines on the Chattahoochee River northeastward to Montezuma on the Flint River; and it is probable that it will be found extending some distance in to Houston county, and further northward, than at present mapped. It lies in contact with the upper Cretaceous sands and marls and occupies parts of the counties of Clay, Quitman, Randolph, Stewart, Webster, Schley, Sumter and Macon. It can be correlated with the Midway group and Chickasaw (Wilcox) group of Alabama and Mississippi. The thickness of the Midway in Georgia along the Chattahoochee River is estimated by J. W. Spencer[1] as 618 feet, while its thickness probably diminishes northeastward.

General Character.—Along the Chattahoochee River, the formation consists of loose sands, calcareous and argillaceous sand, laminated clay and soft, white, chalky limestone. The equivalent of the Midway in Mississippi was named the Lignitic on account of its lignitic character, but in passing eastward from Alabama into Georgia, its lignitic character is not conspicuous. The following section of the river bluff at Fort Gaines, made by the writer, gives an idea of the character of the strata along the Chattahoochee.

Bluff at Ft. Gaines, 200 Yards Below the Wagon Bridge

1	Red sand with small pebbles at the base, (capping the bluff)	15	feet
2	Laminated, silty clay	8	"
3	Yellow and gray sand	12	"
4	Non-indurated, gray, calcareous sand "marl"	20	"
5	Drab, laminated, silty clay	4	"
6	Hard, fossiliferous clay layer	4	"
7	Gray and black, sandy marl. Contains thin nodular limestone layers, and some carbonaceous material	20	"
8	Black and slate-colored mudstone, hard and jointed	12	"
9	Gray, calcareous and argillaceous sands	6	"
10	Nodular limestone	2	"
11	Ash-colored, sandy marl	8	"
12	Gray, calcareous sand	2	"
13	White, massive-bedded limestone	20	"

In Stewart and Randolph counties, the formation is composed principally of friable sands and clays. The sand is vari-colored and is generally highly ferruginous, containing thin limonitic crusts and hollow limonite concretions.

Hollow limonitic concretions with polished and botryoidal interiors, are rather characteristic of the sands of the Mid-

1. Geol. Surv. of Ga., First Rep't Progress, 1890-91, p. 49.

way. It is very often glauconitic; it contains, also, pockets of light colored and white fire clays. Beds of fuller's earth-like clays occur. These latter are thin-bedded, jointed, and fossiliferous; they may contain small siliceous nodules and are often glauconitic.

The strata show some slight crumpling and tilting which is rarely observable in the Coastal Plain sediments. Eastward the formation is mainly vari-colored sand, with thin beds and pockets of light colored massive clays. An exposure of the Midway sand may be seen in a cut of the Atlanta, Birmingham and Atlantic Railroad, a short distance east of Montezuma. The sand is here about 50 feet in thickness; it is generally very fine in texture and shows crossbedding. It is white or light yellow, becoming red at the surface. Underlying the sand there is an exposure of three or four feet of black clay and sand containing iron pyrites, which has been altered to iron sulphate, copperas. In the southern part of Macon and northern part of Sumter counties, extensive beds of white clay occur.

The Clays of the Midway.—The clays of the Midway formation have not been utilized, though there are some localities where they give promise of considerable value for clay products, and will probably be of future commercial importance. The extensive beds of white clay occurring at Kelly Mill and Copperas Bluff in Sumter county are number one fire clays in point of refractoriness. They are described in detail in a subsequent part of this report. In Stewart, Randolph and Quitman counties white clays occur in the sands. These clays are in the form of lenticular beds or irregular pockets in the sands and do not persist over any large areas in continuous strata. They occur much as do the white clays of the Cretaceous. These clay pockets were observed reaching a thickness of 12 or 15 feet and are probably in some instances much thicker. The white clays are massive-bedded, not laminated, and contain only a small amount of sand. They do not reach the degree of purity that the Tuscaloosa clays do, but are otherwise similar in their properties. They have good plasticity, high burning shrinkage, low air dried strength, and are highly refractory. They do not give promise of being suitable for white ware. During field work, white clays were noted at a number of points in northern Randolph county, notably on the property of E. J. Moye, 5½ miles northeast of Cuthbert; in a cut of the Lumpkin-Cuthbert public road, 8½ miles south of Lumpkin, and in the railroad cuts between Hatcher and Georgetown in Quitman county.

The more impure clays of the formation do not have any immediate prospect of value. They are gray, or drab, sandy laminated clays in the nature of fuller's earth, such as may be observed at Fort Gaines, north and west of Cuthbert and at other localities, and there are some black, laminated, highly micaceous clays; and south of Lumpkin and southwest from Richland a greenish-yellow, very tough, waxy clay was noted.

THE CRETACEOUS

The Cretaceous system in Georgia has been divided into:

Upper Cretaceous	Ripley Eutaw
Lower Cretaceous	Tuscaloosa (Potomac)

The above formation names were first adopted by Dr. E. W. Hilgard[1] in a study of the geological history of the Gulf of Mexico. The type locality of the Ripley is at Ripley, Mississippi, and the Eutaw and Tuscaloosa are typically exposed at Eutaw and on the Tuscaloosa River in Alabama. The for-

1. Proc. Am. Assoc. Adv. Sci., Vo. XX, p. 222, 1871; also Am. Jour. Sci., 3rd ser. Vol. II, p. 391.

mations have been studied in some detail in Alabama, and have been traced eastward to the Chattahoochee River.

In Georgia the Cretaceous has been studied along the Chattahoochee River by D. W. Langdon[2] and by Dr. J. W. Spencer[3]. However, but little has been done toward attempting to trace the formations eastward and defining the boundaries of the Eutaw and Tuscaloosa, and the Eutaw and Ripley. From field work by the writer, it has been found that the character of the Eutaw and Ripley strata changes greatly in passing eastward from the Chattahoochee River, and that the Eutaw and Ripley are quite similar lithologically, and the boundary between the two but vaguely defined and the division doubtfully warranted. Inland from the Chattahoochee River no detailed descriptions of the Ripley and Eutaw strata have been published. The Upper Cretaceous strata extends eastward to the Ocmulgee River.

Beyond the Ocmulgee, it has not been recognized, though it doubtlessly occurs, but is concealed by Tertiary strata. The Tuscaloosa lies in contact with the crystalline rocks of the Piedmont region and extends entirely across the State from Columbus to Augusta.

The Cretaceous system in Georgia forms a belt lying in contact with the Crystalline rocks and extending entirely across the State, and forming the northern margin of the Coastal Plain. This belt reaches its maximum breadth along the Chattahoochee River, where it is 50 miles in width; it thence extends eastward to the Ocmulgee River, with a breadth of 20 to 25 miles measured southward from its contact with the Crystalline rocks of the Fall Line. East of the Ocmulgee only a belt of the Tuscaloosa formation occurs, which has been largely overlapped by Eocene sediments, and has a width ranging from nothing to fifteen miles.

Thickness.—The total thickness of the Cretaceous along

2. Geol. Surv. Ala. Rep't on the Coastal Plain.
3. Geol. Surv. Ga. Rep't of Progress, 1890-91.

the Chattahoochee River, was estimated by Langdon[1] as 1,645 feet. The writer is inclined to think, however, that the total thickness of the Cretaceous in western Georgia, will exceed these figures and be nearer 2,000 or 2,500 feet. The record of an artesian well sunk four miles south of the city of Columbus, showed a thickness of 400 feet of strata without encountering any crystalline rock. This would indicate that the crystalline floor is sloping southward at the rate of 100 feet per mile. There is no evidence, however, that this slope is constant for any great distance. The full thickness of the Cretaceous has not been penetrated by wells at any point, and its thickness can be estimated only by the dip of the strata, which is found to be variable.

The Tuscaloosa east of the Ocmulgee River will vary from 50 or 60 to probably 500 or 600 feet in thickness.

The Ripley Formation

General Character.—The Ripley is a marine deposit consisting of unconsolidated sands, clays, clay-marls and a small amount of limestone. Its areal distribution in western Georgia is greater than that of either the Eutaw or the Tuscaloosa. According to the work of Langdon, it extends from Fitzsimmon's Landing on the Chattahoochee to the mouth of Sand Creek in Clay county, a distance of nearly 40 miles. It extends eastward to the Ocmulgee River, but it has not been differentiated from the underlying Eutaw, and its northern boundary has not been definitely determined. The two formations are similar lithologically, and the difficulty of differentiating the two, is further increased by the presence of superficial Columbia sand. It is rather doubtful whether the Eutaw, either by the lithological character of its strata or by fossil evidence, can be traced east of Marion county, and the great thickness of the Upper Cretaceous sands and clays lying

1. Geol. Surv. Ga. Report of Progress, 1890-91, p. 27.

in Taylor, Schley, Macon and Houston counties is best classed as entirely Ripley.

Along the Chattahoochee the Ripley is composed mainly of gray, calcareous, micaceous sands, black clay-marls, and thin layers of nodular, fossiliferous limestones. The limestones are gray in color and form thin beds rarely more than two or three feet in the calcareous sand, and black clay-marl. The black clay-marls are very fine grained, micaceous laminated clays often full of white comminuted shells and sharks' teeth. They may contain iron pyrites and sometimes disseminated gypsums, and are lignitic. The gray, calcareous micaceous sands predominate. They are generally unconsolidated; they often contain fragile fossils and may carry thin layers of calcareous nodules. They also carry laminated sandy clay layers. The following sections will indicate the character of the Ripley strata along the Chattahoochee.

Section at Old Blufftown, Stewart County

1	Red and yellow quartz sand, unconsolidated and containing small pebbles and thin, limonite crusts	100	feet
2	Gray, calcareous, friable sand	50	"
3	Dark-colored limestone layer	4	"
4	Gray, calcareous sand	20	"
5	Nodular limestone, containing Exogyra	1½	"
6	Gray, calcareous sand, containing fragile fossils	12	"
7	Ash-colored, nodular limestone	2	"
8	Gray sand	3	"

Section of The Bluff at Florence, Georgia

1	Crossbedded sand and gravel	10	feet
2	Black, laminated sandy clay-marl, containing fragments of shells	18	"
3	Limestone layer	1	"
4	Black clay	2	"
5	Limestone	1½	"
6	Friable, brown sand, slightly phosphatic	4	"
7	Lignitic sand	5	"

Section at "The Narrows" Near the Mouth of Pataula Creek, Clay County

1	Yellow and red clay soil (altered clay-marl)	5 feet
2	Laminated clay-marl	2 "
3	Nodular, siliceous limestone	2 "
4	Unconsolidated, calcareous sand	6 "
5	Calcareous sandstone	1 "
6	Gray and black clay-marl	5 "
7	Coarse-grained, gray calcareous sandstone, fossiliferous	5 "
8	Gray, micaceous sand	5 "
9	Layer of calcareous sandstone	1 "
10	Black, clay-marl, very fossiliferous	3 "

The following subdivisions of the Ripley will hold in a general way in the counties of Chattahoochee, Stewart, Marion and Quitman. The divisions were made purely upon lithological character and not upon paleontological evidence.

		Thickness
Ripley	Upper sand (Providence) unconsolidated	150 feet
	Upper (Renfroes) marl	500 "
	Middle (Cusseta) sand (unconsolidated)	250 "
	Lower (Blufftown) marl	200 "

The thickness given is only tentative. There is no sharp line of contact between the divisions given, and they will be found grading into each other. Also the division will doubtless hold eastward, although the upper marl formation can be traced eastward to Ideal on the Atlanta, Birmingham and Atlantic Railroad in Taylor county, and may be found on the Flint River, and in Houston county.

The upper sand is exposed best in the deep gullies at Providence, eight miles west of Lumpkin, where 150 feet of yellow, white, red and purplish crossbedded sand may be seen. In the bottom of some of the gullies, the black lignitic and pyritiferous clays of the upper or Renfroes marl appear. From the black clay to the overlying sand, there is a gradual transition, with no unconformity observable, showing that the sand and marl are only phases of one continuous deposition. The Cretaceous sand is overlain by a bright red sand, in which, at a few localities, bowlders of fossiliferous, siliceous limestone are found, and which are probably Eocene.

The upper marl formation consists of massive, gray, micaceous, calcareous sands, with layers of nodular limestones; black plastic clays fossil-bearing; and various colored sands with layers of laminated, silty clays. The formation may be seen east of Louvale, in the vicinity of Hichitee, northeast of Buena Vista, between Buena Vista and Tazewell, and in the railroad cuts of the Atlanta, Birmingham and Atlantic Railroad near Ideal. This marl belt is probably not at any point more than 4 or 5 miles in width; the soil produced by it is more fertile than that of the sand members, and when not obscured by superficial sand, the area underlain by it can almost be traced by the character of the vegetation, which it supports. It weathers into a red or yellow "sticky" clayey soil.

The following is a detailed section of the upper marl formation as it occurs at Johnston Hill, 4 miles north of Lumpkin:

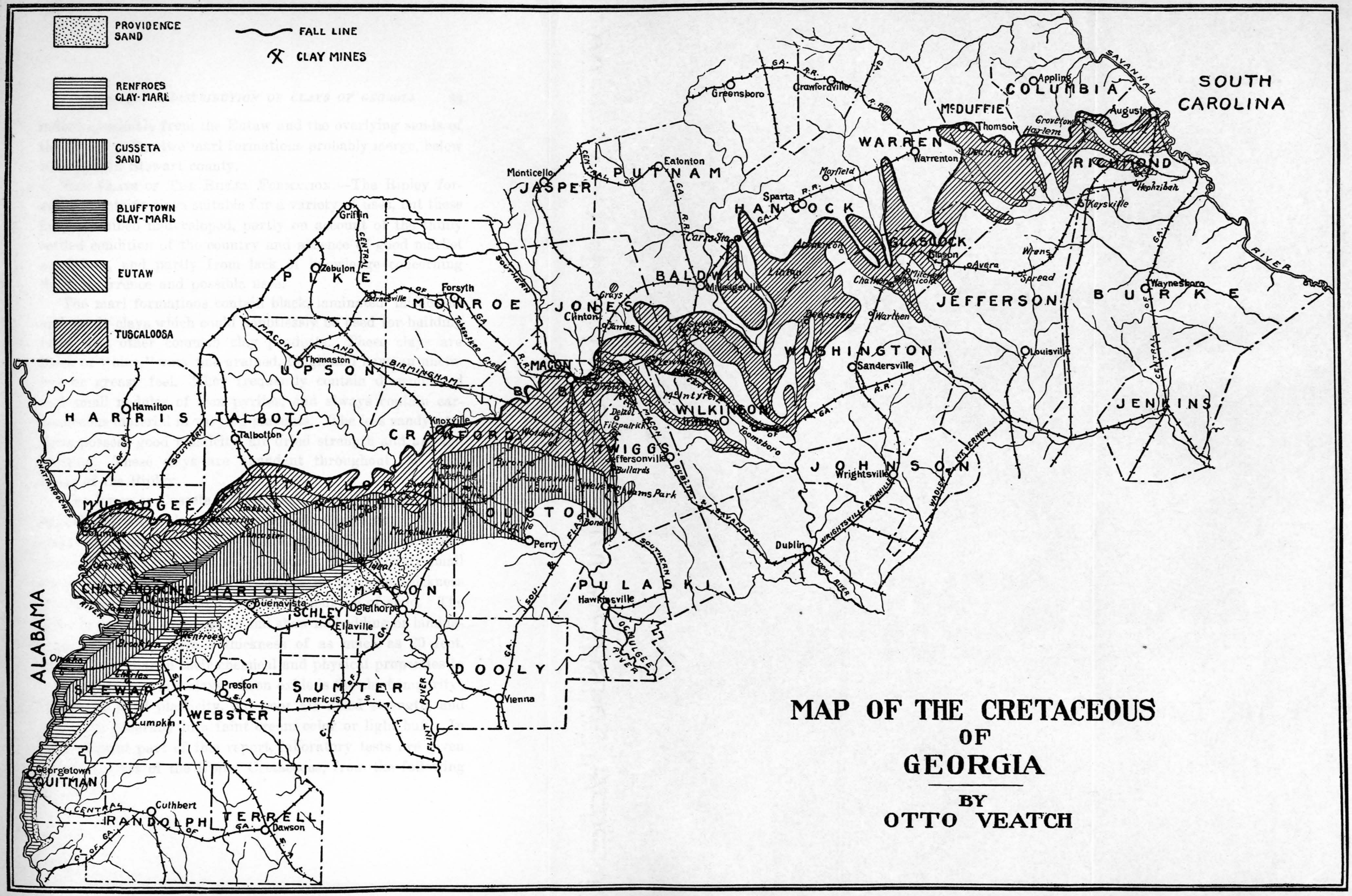
1	Unconsolidated red sand	30	feet
2	Drab, laminated clay	6	"
3	Calcareous clay, containing lime concretions	10	"
4	Limestone layer	1	"
5	Clay-marl	3	"
6	Limestone	1	"
7	Clay	1	"
8	Nodular limestone	1	"
9	Gray, sandy, micaceous and argillaceous marl	20	"
10	Nodular limestone	1	"
11	Clay,marl	4	"
12	Limestone	10	inches
13	Marl	5	feet
14	Nodular limestone	1	"
15	Black and gray sandy marl	20	"

A good exposure of the upper marl may be seen along the Tazewell public road, 3½ miles northeast of Buena Vista. About 75 feet of fossiliferous calcareous sands and clays are exposed. The thin nodular limestone layers which are common to the westward do not appear. The beds are mainly gray argillaceous sands and black lignitic clays.

Underlying the upper or Renfroes marl there is a great thickness of non-calcareous sands and clays. These sands are well exposed in the vicinity of Cusseta, and the formation name, *Cusseta,* is provisionally adopted. The sands are made up of quartz and mica, are unconsolidated, vari-colored, and generally fine grained in texture. They are unfossiliferous except for lignitized and silicified wood, and they are often very ferruginous, containing thin crusts and layers of siliceous limonite and limonitic nodules. In the sands are pockets of white, drab, and black, massive-bedded clays, and also thin lenticular layers of laminated clays. A good exposure of a clay lens in the Cusseta sand, occurs in a gully along the Tazewell road 6 miles northeast of Buena Vista. The clay is both light and dark colored and massive bedded; it contains well preserved fossil leaves and minute cubes of pyrite.

The clay feature, however, is subordinate, and the formation is predominately loose, crossbedded, vari-colored sand. In the absence of the Eutaw formation, the great thickness of sands and clays in the southern part of Taylor, northern part of Macon, and northern part of Houston counties, may be referred to this formation. In Macon and Houston counties the sands contain pockets of very pure, white clays. Extending eastward from Cusseta to the Ocmulgee River, the sand formation has a width of from 5 to 15 miles. It may reach a maximum thickness of 600-800 feet.

The lower marl formation of the Ripley, here, provisionally named the Blufftown marl, is similar in its lithological character to the upper or Renfroes marl, and is composed of black, lignitic clays, gray, calcareous and argillaceous sand and thin layers of nodular calcareous rock. It occurs in the bluffs of the Chattahoochee River, and is seen in a cut of the Seaboard Air Line Railroad, three miles north of Cusseta. It is not of as wide areal distribution as the upper marl, and can not be traced eastward with any certainty since it becomes



MAP OF THE CRETACEOUS OF GEORGIA

BY

OTTO VEATCH

indistinguishable from the Eutaw and the overlying sands of the Ripley. The two marl formations probably merge, below Florence, in Stewart county.

THE CLAYS OF THE RIPLEY FORMATION.—The Ripley formation contains clays suitable for a variety of uses, but these have remained undeveloped, partly on account of the thinly settled condition of the country and absence of good market conditions, and partly from lack of knowledge concerning their occurrence and possible uses.

The marl formations contain black, laminated, micaceous and sandy clays which could doubtlessly be used for building brick and other common clay products. These clays are black or "blue," very fine grained, tough and have an unctuous or greasy feel. They frequently contain disseminated and small nodules of iron pyrites, and always contain carbonaceous material in varying amounts. The less sandy portions possess good plasticity, air dried strength and are red burning. These clays are abundant throughout the marl areas of the Ripley.

The lower or Cusseta sand formation of the Ripley bears deposits of white clays which are highly refractory. These clays occur much as do the white clays of the Tuscaloosa along the Fall Line, that is in pockets of comparatively small areal extent and in lenticular layers of variable thickness which may grade into and be split by tongues of sand. The clays in question, are massive and show no bedding or lamination. They may have a thickness of as much as 20 feet. They are similar in their chemical and physical properties to the Tuscaloosa white clays. Iron oxide is the chief impurity; they have good plasticity, but poor air dried strength, and will burn generally to a faint cream color or light buff. In a subsequent part of this report, laboratory tests are given on white clays of the Upper Cretaceous, from the following localities: Fort Valley, Perry, Marshallville, Maverick, Bonaire.

The Eutaw Formation

The Eutaw formation consists of sands, laminated clays, and calcareous sands and clays. It is predominately, however, a sand formation. Along the Chattahoochee River and in Chattahoochee county it does not differ greatly lithologically from the Ripley formation, the calcareous sands and black or dark colored, laminated clays of both formations being quite similar. This division is based upon paleontological differences. The Eutaw, however, presents marked differences from the underlying Tuscaloosa, in being calcareous, fossil bearing and of marine origin. The formation is perhaps more lignitic than the Ripley and also contains large silicified logs and trunks of trees.

The Eutaw is not of wide areal distribution in Georgia. It underlies the northern part of Chattahoochee county and a small area in the southern part of Muscogee county. Eastward in Marion county, it becomes largely unconsolidated red and brown sands which contain fragments of wood and large silicified logs; there are also deposits of dark colored, laminated clays, with sand partings, which carry fragments of lignitized wood. The formation becomes quite similar lithologically to the sands of both the Ripley and the Tuscaloosa, and the difficulty of tracing it is further increased by a covering of superficial Columbia sand.

The following is a section by D. W. Langdon,[1] of the Eutaw series as exposed along the Chattahoochee River:

1 Dark-gray calcareous sand, pyritous, and containing nodular masses, 6 to 12 inches in diameter, with calcite nuclei, These nodules are arranged in strata, about two feet apart, and terminate in an indurated stratum, about 12 inches thick. Small fragments of lignite are scattered about through this stratum, and one or two large masses filled with calcified teredos are found. The only other fossils seen were an *Anomia* and an *Exogyra*, probably the young of E. *costata*, Say. The fossils are all poorly preserved. Dip at this point 40 feet to the mile, southward.......... 15 feet

1. D. W. Langdon, Geol. Surv. Ala. Rep't on the Coastal Plain, p. 439.

2	Gray sand, of the same nature as the preceding, only no nodules were seen; and the shells increase in quantity, particularly in the lower part. The upper part of this stratum becomes argillaceous and contains many fossil casts, mainly lamellibranchs; causes landslides in the banks, like the Black Bluff clays, which they resemble somewhat, physically. These sandy clays give rise to Uchee Shoals..	100	"
3	Laminated, dark gray clays, with masses of yellow sand distributed, at irregular intervals, throughout the stratum; best developed just above the mouth of Uchee Creek, Alabama	25	"
4	Yellow and white sand, with thin seams of lignitic sand, and an occasional "bunch" of gray, laminated clay. These sands are exposed in a bluff about 100 yards from the river, just below the mouth of Rooney's Mill Creek, Ga..	50	"
5	Quartzose conglomerate, much like that at Havana, Hale county, Alabama; forms the shoal at Beden's rock, and the bluff at Hatcher's lower landing; merges gradually into a yellow sand........	50	"
6	Yellow sand and gray clay, containing bits of leaves. This stratum and the following are seen at Chimney bluff, Ga..	60	"
7	Light yellow and white sands, containing beds of well rounded quartzoze pebbles, sometimes 20 feet thick. Lignitized logs can be seen protruding from the bluffs. The sand contains a small *Exogyra* at rare intervals. The supposed top of the Eutaw group........	45	"

A good exposure of the Eutaw strata may be seen in the bluff of Upatoi Creek, near the Seaboard Air Line Railroad bridge, 7 miles southeast of Columbus. The lower 50 feet of the hill consists of gray calcareous and argillaceous sand; overlying this are 20 feet of black clay marl and impure nodular limestone. This latter formation is very fossiliferous, and contains pyrite, lignite and gypsum. The upper 30 feet consists of brown and gray calcareous sands.

The section in the bed and bluff of the creek at Ochille is:

1	Brown or yellow unconsolidated sand (at top)........		feet
2	Blue or black laminated, sandy clay, "marl"	40	"
3	Sandstone	4	"
4	Dark gray, calcareous sandstone. In places the bed is composed almost entirely of shells........	4	"
5	Black and gray micaceous, calcareous sand, contains poorly preserved shells and lignite........	8	"

Eastward in Marion county the formation is largely brown, red and yellow crossbedded unconsolidated sand. A few exposures of dark colored laminated clays were noted.

CLAYS OF THE EUTAW.—Black and dark colored laminated clays with sandy partings occur in the formation and may be suitable for building brick, though they offer no prospect of immediate value. No white clays or clays approaching kaolin in composition were observed.

THE TUSCALOOSA FORMATION

The lowest member of the Cretaceous system is the Tuscaloosa (Potomac). It consists of coarse grained crossbedded, generally unconsolidated sands, and white and stained kaolins and fire clays. It is the most important clay bearing formation in the State, containing the valuable kaolins and fire clays of the Fall Line. In his study of the Fall Line clays of Georgia, Dr. G. E. Ladd[1] used the formation name, *Potomac* for the Lower Cretaceous and this term is perhaps more familiar to the people of the State than *Tuscaloosa*. The latter term, however, is retained in this report for geological reasons. The formation is the equivalent of the Tuscaloosa formation of Alabama and Mississippi and can be correlated with the Hamburg[2] formation of South Carolina. The age of the formation in Georgia is determined only by its stratigraphic position and has not been established by any fossil evidence, either plant or animal.

The Tuscaloosa rests unconformably upon the eroded surface of the ancient metamorphic and igneous rocks of the Piedmont Plateau, and there is an enormous time interval between the ages of the two. In the western part of the State the Tuscaloosa is overlain with doubtful unconformity by Upper Cretaceous strata; east of the Ocmulgee River, the clays and red sands of the Claiborne group rest upon its

1. Geol. Surv. of Ga., Bulletin No. 6-A.
2. E. Sloan, Bulletin South Carolina Geol. Surv.

eroded surfaces and may entirely obscure it. It is questionably overlain by the Lafayette at any points except near Columbus, Macon and Augusta or at points along the larger rivers entering the Coastal Plain, the Lafayette not occurring on the divides between the rivers. It is generally overlain by the Columbia sand (Pleistocene) with a thickness of 5 to 50 or 60 feet. The Columbia is a mantle of brown or gray, incoherent, structureless sand, and is easily distinguished from the Tuscaloosa and the Tertiary sands.

Character of the Strata.—The Tuscaloosa formation consists entirely of sands, gravel and clays, generally unconsolidated. The formation has not yet been subdivided into minor formations, and this will be found difficult on account of the variability of the strata and lack of persistency of individual beds. However, as the formation is studied more in detail, and the commercial development of its clays proceeds, local classifications of beds will doubtless be made. On the whole, the formation is homogeneous, and the character of the material composing it, is generally similar throughout its area in Georgia.

The sands and clays of the formation are intimately mixed and grade into each other, though for convenience of description they will here be discussed separately. The sand of the Tuscaloosa is composed principally of quartz in small angular particles; muscovite mica is next the most abundant mineral, and small amounts of hornblende or augite, garnet and magnetite have been observed. Feldspar in various stages of decomposition occurs, while the sands are often colored by iron oxide, limonite and hematite. The sand is generally coarse grained, and near the contact with the crystalline rocks, beds of gravel and large subangular fragments of quartz occur. The sand possesses but little structure, and there has been but little disturbance of the strata since its deposition. It is crossbedded and unconsolidated except at a few local points. It forms the greater part of the formation, on a broad estimate 75 per cent. of the whole.

The clays are white and stained, massive bedded and approach kaolins in chemical composition. They are fine grained, and vary greatly in the amount of their sandy impurities. The clays will be described in more detail subsequently.

THICKNESS.—The Tuscaloosa formation will vary in thickness from only a few feet near its contact with the crystalline rocks of the Piedmont Plateau, to 500 or 600 feet. The character of the formation is such that its thickness can not be determined from geological exposures, and well records, when at hand, are relied upon. In the vicinity of Columbus the formation is known to reach a thickness of 400 feet; in Crawford and Bibb counties it will probably reach a thickness of 400 to 600 feet, and east of the Ocmulgee River, it will vary from 50 or 60 to 500 or 600 feet.

DISTRIBUTION.—The Tuscaloosa forms a narrow belt extending entirely across the State from Augusta to Columbus. It lies in contact with the crystalline rocks of the Piedmont Plateau and its northern margin is the northern margin of the Coastal Plain. West of the Ocmulgee River, the belt is from 3 or 4 to 8 or 10 miles in width; east of the Ocmulgee it is largely overlapped by the sands and clays of the Claiborne group and superficial sand, so that in many places it may not appear at the surface at all. It is best exposed along the streams, which have cut through and eroded the overlying formations. It is seldom seen outcropping more than 15 miles south of its contact with the crystalline rocks.

ORIGIN.—The material composing the Tuscaloosa formation was derived from the disintegrated and decomposed rocks of the Piedmont Plateau. The formation is of freshwater origin, being deposited in bodies of fresh water lying off shore or inland.

Occurrence of the Clays of the Tuscaloosa.—The clays occur as pockets or lens-shaped beds enclosed by sand and are of comparatively small extent; and in the upper part of the formation, as thick, extensive horizontal beds lying in contact with later sands and clays. The small lens-shaped beds are often of remarkable purity but are of small thickness and may grade into sand abruptly. The thickness of the clays will vary from a foot or two to as much as 35 feet, and their extent will vary from a hundred yards to several miles.

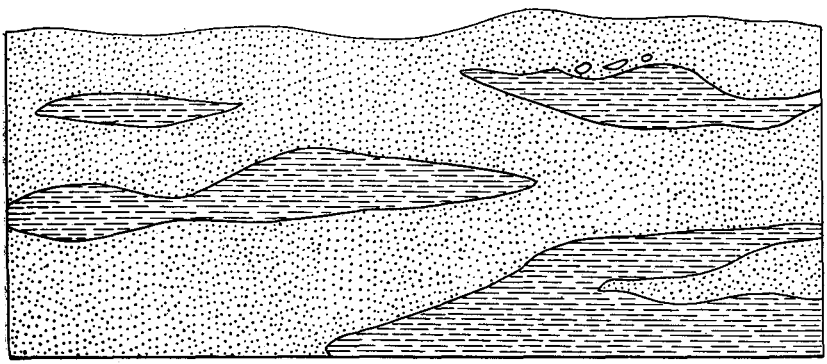


Fig. 4.—Generalized Sketch Showing Lens-Shaped Beds of Clay in Sands, which is characteristic of the Clays in the Tuscaloosa Formation in Georgia.

In the eastern belt of the Tuscaloosa or that part lying east of the Ocmulgee, the clays are found to reach the greatest thickness and occur in the greatest quantity. In the lower part of the formation or that nearest the contact with the crystalline rocks, the clay beds will be found generally lenticular in shape and of small extent, though in commercial quantities. Good examples may be seen in the railroad cuts at Carr's Station and Griswoldville. At these places, the full extent of a clay bed may be seen within the length of the cut. The bed will have a maximum thickness in the middle and taper to points at each end. These beds may reach a maximum thickness of 8 to 10 feet and then thin out completely.

Their upper surfaces are often undulating and gullied, having been eroded during the deposition of the overlying sands.

In the Dry Branch region and in the vicinity of Gordon and McIntyre in Wilkinson county there are clay beds of great thickness and areal extent. They do not thin out rapidly and are more uniform in texture and thickness than the lower clay beds. Variations in thickness may occur, however, due to old erosion gullies, formed previous to the deposition of the overlying Eocene sands, and the beds may vary from 10 to 35 feet in thickness. The white clays are sharply contrasted with the overlying Eocene red sands and clays, but below, may change gradually or abruptly into sand, but the contact between the lower or Cretaceous sand and the clay is never sharp.

The white clay beds of the western belt of the Tuscaloosa are similar in their occurrence to those of the eastern belt, though the beds are not as thick and individual beds are not as extensive areally.

The structure of the clay beds is quite simple. They occur in massive layers which represent a continuous deposition and do not show lines of stratification or lamination as are usually seen in clays and shales of sedimentary origin. The beds lie almost horizontal and show no appreciable faulting or fracturing, facts of considerable importance in the mining of and prospecting for the kaolin and fire clay, since a bed may be easily traced by levels and the amount of overburden and the quantity and position of the clay estimated with some certainty. The beds are but little disturbed from their original positions and only purely local movements have taken place.

Jointing is prominent in the more massive beds as at Dry Branch and Hephzibah. There is, however, no system of jointing and the joints are really irregular cracks which seem to be due to tension caused by the shrinkage from loss

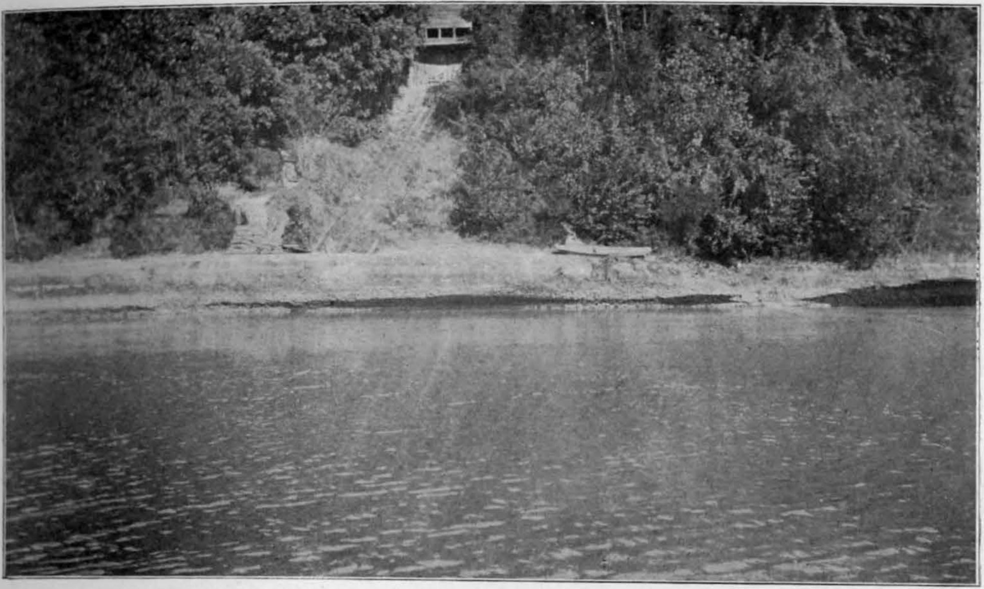


FIG. 1.—MIDWAY LIMESTONE, FORT GAINES.

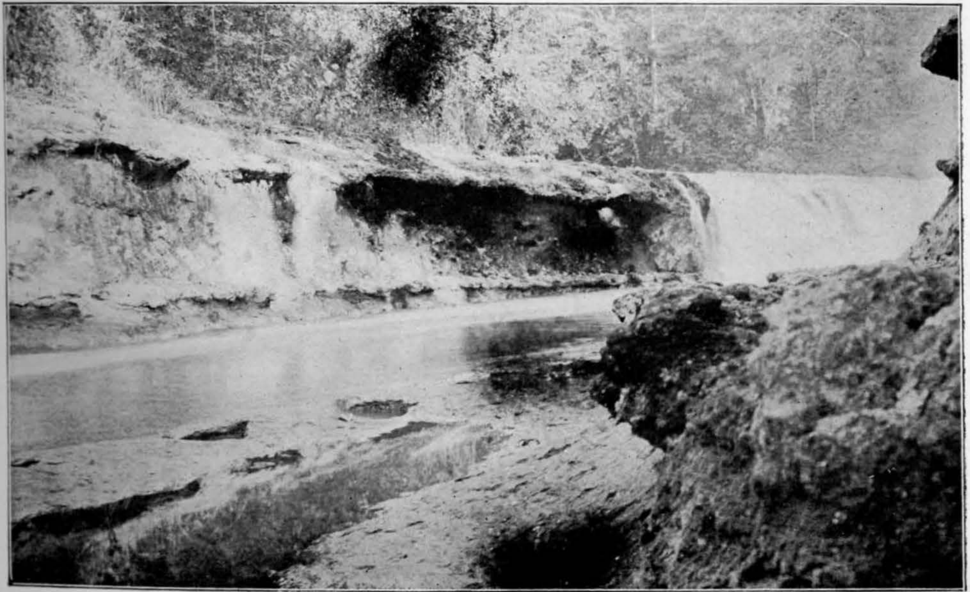


FIG. 2.—CRETACEOUS STRATA, PATAULA CREEK.

of water, and partial consolidation of the clay. The joint cracks may be oblique, vertical or horizontal; in the soft clays the joint cracks do not extend for any great distance either horizontally or vertically and the jointing is not close, but there may be considerable space between joints. The jointing is an efficient aid in the mining of the clay. In the hard and semi-hard clays, the jointing may be minute, and the clay will break into small angular blocks only a few inches square. The joint crack may vary from 1/100 to ¼ inches in width and are usually filled with limonite deposits and manganese oxide scales, which have been deposited by infiltrating waters from the overlying sands.

Slickensided, or smooth, polished and striated surfaces are noted along the joint planes. This phenomenon is due to the movement of one mass of clay over another. Water enters the joint cracks and acts as a lubricant for the already unctuous or "greasy" clay, while the movement is effected by the downward pull of gravity. Slickensided surfaces were especially observed in the pits of the Georgia Kaolin Company at Dry Branch.

A nodular or concretionary structure in the clay has been observed at a few localities. Nodular white clay was observed on the Z. T. Miller place in Wilkinson county, and a pitted structure due to the weathering out of clay nodules occurs in the clay at O'Connor Hill near Grovetown. This is a secondary structure due to an alteration of the clay after deposition. The alteration has proceeded so far at one locality, 3 miles northeast of McIntyre, that a rather extensive deposit of pisolitic bauxite has resulted.

Theory of Origin and Deposition[1]

The white clays of the Tuscaloosa in Georgia are clearly of sedimentary origin, and were derived from the northward

1. The theory as here given is essentially as previously published by the author in Economic Geology, Vol. III, No. 2.

from the crystalline rocks of the Piedmont Plateau. The greater part of the Piedmont Plateau from which the Lower Cretaceous was derived, is composed of granites, gneisses and feldspathic schists, cut by basic trap dikes, and diorite intrusions. The basic dikes and basic diorite intrusions form only a small part of the whole area and the latter are themselves cut by granite intrusions and pegmatites. The region, then, is on the whole a highly feldspathic one, and the weathered residue of its rocks is consequently highly argillaceous. The red soil, so characteristic of the Piedmont Plateau, is after all, only a surface phenomènon; and, with the exception of certain small areas, which are underlain entirely by basic eruptives, it is underlain by gray or white decomposed and disintegrated rocks, the feldspars and other aluminous minerals of which have altered to kaolinite or allied minerals.

The greater part of the Piedmont region has been a land surface since the close of Cambrian time, and the amount of weathering of its rocks, effected during the great intervals of time represented by the Silurian, Devonian and Carboniferous epochs, was perhaps as great during the Cretaceous period as at present. Subsequent to the deposition of the Carboniferous strata and just before the beginning of the Cretaceous, the Piedmont region suffered a great uplift with a tilting to the southeast. The result of this movement was a rejuvenation of the drainage, the direction of which was essentially the same as at present; and the streams set rapidly to work carrying the weathered residue down to the Cretaceous sea.

The steepness of the slope of the ancient Piedmont region may in a measure be inferred from the steepness of the crystalline floor now overlain by Coastal Plain sediments. This floor slopes southeastward 50 to 75 feet per mile; the altitude of the land during the Cretaceous must have been much greater than at present. As a result of steep gradient, streams were very active, perhaps torrential in character, which is indicated by the frequent coarseness of sediment and evidences of rapid deposition, and the deeply weathered material of granites and gneisses in the main was picked up and dumped on the shore of the Cretaceous ocean as alluvial fans or at the mouths of streams as deltas, the delta of one stream mingling with and overlapping that of another. An enormous amount of sediment rapidly dumped at the mouths of streams resulted in the formation of sand flats, in the formation of fresh water delta lakes, and possibly in the enclosing of areas of sea-water by sand barriers, which were at once freshened by the inflow from land streams. In the deeper and quieter waters of off-shore lakes and sounds, the fine clay particles were deposited in non-persistent and lenticular beds of pure white clay, while in the shallower water under conditions of shifting currents, the crossbedded sands and, occasionally, beds of pebbles were laid down. Conditions, however, did not remain uniform for any great length of time. One set of barrier lakes formed were filled up and other lakes formed. Layers of sand and clay were laid down, subsequently subjected to the action of currents, partly eroded and redeposited. The evidence of this is the abundance of clay pellets, pebbles and large angular chunks of white clay mingled with sand and superimposed unconformably upon white clay beds.

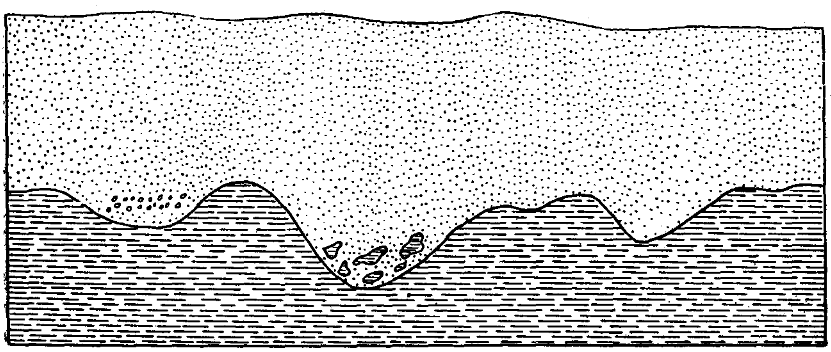


Fig. 5.—Sketch Showing an Erosion Unconformity between Clay and Sand.

The entire absence of marine conditions supports this theory. No marine shells or any animal remains whatever have been found in the Tuscaloosa in Georgia. Also, very strangely, there is so far as is known at present, an absence of plant remains in the Tuscaloosa. This fact is difficult of explanation, since clays are favorable for the preservation of plants and since an abundant flora has been found in other States in formations which are regarded as synchronous with the Tuscaloosa in Georgia; and when it is known that the beds of the Upper Cretaceous which closely succeeded it in deposition are lignitic and contain abundant plant remains. The Upper Cretaceous directly overlies the Tuscaloosa and succeeded it in deposition without any interval during which there was uplift or land period. In the Lower Cretaceous there are no lime nodules or even calcareous layers of any description, no traces of sulphides (pyrites) or sulphates have been observed either in the sand or clay; manganese nodules which indicate marine conditions, are not found as an original constituent in the Tuscaloosa; no trace of gypsum which might indicate brackish water or lagoons, is found. In short, the chemical composition of the Tuscaloosa strata as a whole is the composition of the residue of weathering of the Piedmont Plateau. Much of the material of the Tuscaloosa is arkose, the deposition of the Piedmont residue without sorting.

The remarkable purity of the kaolin, as indicated by the following analysis, is difficult of explanation. The analysis is from a sample of kaolin from one of the mines at Dry Branch, and represents the condition of the clay in a state of nature, the sample having received no washing or other mechanical treatment.

Moisture at 100° C.	.93
Loss on ignition	13.73
Silica	44.97
Alumina	38.51

Ferric oxide	.51
Manganese oxide	.00
Lime	.00
Magnesia	.16
Sodium oxide	trace
Potassium oxide	trace
Titanium dioxide	1.36
Sulphur	.00
Phosphorous pentoxide	.00
Total	100.17

Rational analysis:

Feldspar	.00	Sand	.33
Quartz	.33		
Clay substance			99.67
Total			100.00

It is not to be assumed that the entire thickness of a kaolin bed is as pure as the above sample, for the beds as a whole, contain impurities, and the higher grades of clay are selected in mining, though the whole thickness of a bed may be white and comparatively of great purity.

In explanation of this remarkable purity, it would seem that nature operated a clay washing plant on a grand scale. The process was in the main that employed in washing a residual kaolin. The Piedmont Plateau was a vast residual kaolin deposit; to be sure the greater part of this deposit consisted of impurities such as particles of quartz, mica and smaller amounts of other minerals found in igneous rocks, which were subject to disintegration and decomposition by weathering agencies. The kaolin or kaolinite was derived mainly from the decomposition of the feldspars, though doubtless other minerals contributed to the amount in no small way. In the separation process, much of the coarser material and large rock fragments was dropped by streams in transit to the ocean, or at the debouchure of the streams, while the finer material, clay and sand, was carried further outward. Separation of the kaolin from the mass was effected by the specific gravity of the minerals, and the fineness of grain, the latter having perhaps greater influence than the former. The specific gravity of quartz and kaolinite, for example, is nearly the same, 2.6, but the quartz never reached the degree of fineness of the kaolinite particles. Mica, because of the nature of its crystallization and the degree of fineness which the particles reached, remained in suspension easily, which accounts for its being such an abundant sandy impurity in the clay beds. Biotite and other iron-bearing minerals must have been largely altered by leaching before their deposition, since they are comparatively rare either in the sands or clays of the Tuscaloosa.

On account of the brilliant red color of the soil of the Piedmont Plateau, the clay derived from it would be expected to have a high percentage of iron and be colored, and the whiteness of the kaolins is perplexing. The iron bearing minerals, silicates and magnetite, have generally a higher specific gravity, and never reached the degree of fineness of the clay, and, hence, did not remain as readily in suspension, and the absence of any high percentage of iron in the kaolin may be thus partly accounted for. Also, the red color of the Piedmont hills is due in the main to a coating of red iron oxide over quartz and other mineral particles, and often a decidedly smaller percentage, of iron oxide is present in the residual clay than would be imagined from a casual examination. The following analysis[1] of a Piedmont red residual clay will illustrate:

SiO_2	56.99
Al_2O_3	26.02
Fe_2O_3	1.91
CaO	.75
MgO	.17
Na_2O	1.91
K_2O	2.40
Ignition	9.76
Total	99.91

1. T. L. Watson, Geol. Surv. Ga. Bulletin 9-A, p. 87.

This is described as a bright red residual clay derived from a biotite-granite. It will be observed that the percentage of Fe_2O_3 is only 1.91 per cent.

Compared with the depth of residual decay, the red color, as mentioned above, is only a surface phenomenon, extending only a few feet in depth, and the great mass of underlying decomposed and disintegrated material is a mottled, gray or even white color. It was principally from this great mass of gray or white residue that the kaolin beds were derived. The clay particles being finest and of low specific gravity were carried furthest and dropped in the deepest and stillest water of the off-shore bodies described above. The impurities in the clay, as thus deposited, were only the very fine sand and some iron oxide, which may have formed a coating over the clay particles or fine sand grains. The greater part of the fine red and yellow iron oxide was dropped with the coarse sand grains, over which it formed a coating, or with which it was intimately mixed and not easily separable.

The entire absence of or only a small percentage of lime and magnesia is due to the fact that only a very small percentage of the lime and magnesia bearing minerals, of the igneous and metamorphic rocks of the Piedmont Plateau, reached a sufficient degree of fineness to be deposited in the stiller water with the clay. The Lower Cretaceous is not a marine deposit; there is no evidence of animal remains, and conditions were not favorable for chemical deposits of lime or magnesia carbonates and sulphates.

There is no evidence whatever of impurities having been leached from the clay beds after deposition. On the contrary, the beds are probably more impure now than at the time of their deposition, on account of the infiltration of impurities from the overlying Tertiary formations.

Chemical and Physical Properities.—The clays of the Tuscaloosa are white and stained clays, comparatively pure, and approach kaolins in chemical composition. Selected samples show as high as 99 per cent. clay substance. The purest clays, kaolins and high grade fire clays, run from 40 to 50 per cent. silica, and 34 to 40 per cent. alumina. Iron oxide, is the chief impurity and varied in the samples analyzed from .51 per cent. to 2.11 per cent.; lime and magnesia are entirely absent or occur in only very minute amounts; the percentage of alkalies is always very small—potash usually exceeds soda. Titanium dioxide is always present, sometimes as much as 1.5 and 2 per cent., but as far as the writer was able to ascertain in the laboratory, it produces no noticeable coloring effect, and its fluxing effect is inappreciable. Sulphates and organic matter are rarely present.

In texture, the Tuscaloosa clays are themselves very fine grained, but they may often contain rather coarse sand grains. Sieve tests on some samples of the crude clays showed about 95 per cent. passing a 200 mesh sieve. In hardness the clays vary from very soft, cheese-like, to semi-hard or slightly mealy, and very hard or flint clays which can not be scratched with the finger nail. Good examples of the soft and semi-hard clays occur in the mines at Dry Branch and Hephzibah, while the hard clay on the Glover place near Gibson is an example of the flint clay. With the exception of the flint clays all of the Tuscaloosa clays develop good plasticity, but usually have low air dried strength. In some notable exceptions, however, pure clays, were found which showed a maximum air dried strength of 135 pounds per square inch. Most of the clays will show from 10 to 20 or 30 pounds per square inch.

The air shrinkage is usually low, while the fire shrinkage is high and the clays show a strong tendency to crack and check in burning. Leaving out the exceptionally ferruginous clays, the Tuscaloosa clays burn pure white, cream color or buff, depending upon a number of variable factors. The fusing points of the better clays are high, ranging from cone 30, 3,146° F., to cone 36, 3,362° F.

LOCALITIES.—The following are localities where the Tuscaloosa strata may be seen and where their clays are being mined or utilized. The development of the clays has hardly begun and they are certain in the future to be the basis of large industries.

The clays are being mined extensively in Twiggs county in the vicinity of Dry Branch. The following companies are engaged in mining kaolins and fire clays: Georgia Kaolin Company; Atlanta Mining and Clay Company; American Clay Company; I. Mandle and Company. Good exposures showing the mode of occurrence, and character of the clays may be seen in the pits of the above named companies.

The clay is also being mined at Hephzibah in Richmond county, by the Albion Kaolin Company and excellent exposures of both hard and soft clays may be seen here.

At Carr's Station, on the Georgia Railroad in Hancock county, the full thickness of the Tuscaloosa strata at this point may be seen, as well as their relations to the underlying crystalline rocks and the overlying Columbia (Pleistocene) sand. The mode of occurrence of the clay is also clearly revealed.

In the railroad cuts at Griswoldville, the occurrence of the clays is revealed and deep erosion unconformities and the relation of the Tuscaloosa to the red argillaceous Eocene sands are displayed.

At Butler in Taylor county, white clays reach a thickness of 20 feet and have been mined at one locality. The clays of the Tuscaloosa are being utilized for fire brick, sewer-pipe, etc., at Stephens Pottery, by Stevens Brothers and Company.

Other localities where clays are known to occur of good quality and are accessible are: Lewiston, Gordon, McIntyre, Toomsboro, Chalker, Gibson, Grovetown, Thomson, Byron, Rich Hill, and Butler.

CARBONIFEROUS

The Carboniferous strata are confined to the Paleozoic area or to the northwestern portion of the State. The following are the subdivisions of the system as mapped in the Ringgold, Rome and Stevenson (Alabama-Georgia) folios of the U. S. Geological Survey:

Carboniferous	Walden sandstone
	Lookout sandstone
	Bangor limestone
	Ft. Payne chert
	Floyd shales
	Oxmoor sandstone

The Walden sandstone and the Lookout sandstone form the Coal Measures, and the remaining formations the Lower Carboniferous or Mississippian series.

Walden Sandstone

The Walden sandstone forms the uppermost Carboniferous rocks in Georgia. The formation overlies the Lookout sandstone and caps, and is confined in its areal distribution to Lookout, Sand, and Pigeon mountains, in Dade, Walker and Chattooga counties. The formation consists of conglomerate, sandstone, and shale, with several seams of coal. The shales of the formation are highly sandy and micaceous and may pass into pure sandstones. The formation attains a maximum thickness of 930 feet.[1]

Clays of the Walden Sandstone.—The shales of the Walden sandstone on account of their generally highly siliceous character and their inaccessibility, offer no immediate

1. C W. Hayes, Ringgold Folio, U. S. Geol. Surv.

prospect of being of value for clay products. The so-called "fire clays" underlying the coal seams have not been thoroughly tested, but are of doubtful refractoriness. At the few localities examined by the writer they were very sandy micaceous and a yellow or drab in color and contained bits of plant remains. A sample from the Durham Mines was tested for its refractoriness, but its fusing point was found to be quite low.

The conglomerate and sandstone phases of the formation yield no clays likely to be of value.

The following is a section[1] of the strata of the Walden sandstone.

1	Coarse-grained, heavy-bedded sandstone	40	feet
2	Sand shale (partly concealed)	50	"
3	Sandstone	40	"
4	Shaly sandstone (partly concealed)	120	"
5	Black shale, with thin parting of coal	12	"
6	Sandstone	10	"
7	Coal	4	inches
8	Sandstone, crossbedded	60	"
9	Shale	20	"
10	Coal	22	"
11	Shale	8	"
12	Coal	20	"
13	Fire clay	2	feet

Lookout Sandstone

The Lookout sandstone consists of sandstones, conglomerates and shales, with a few thin layers of limestone. The formation directly underlies the Walden sandstone, and is folded into the broad synclines of Lookout, Sand and Pigeon mountains. The formation reaches a thickness as estimated by Hayes[2] of 550 feet. The total area underlain by the formation is quite small—aside from the small areas on the slopes of the above mountains there are two small isolated patches capping Rocky and Little Sand mountains east of Taylor Ridge.

1. S. W. McCallie, Ga. Geol. Surv., Bulletin 12, p. 39.
2. Ringgold Folio, U. S. Geol. Surv.

The upper part of the formation, attaining a thickness of 100 feet or more, consists of a coarse, crossbedded sandstone and conglomerate; underlying are sandy and argillaceous shales and thin bedded sandstone. Some thin beds of dark colored, argillaceous shales occur in the upper sandstone. Prof. S. W. McCallie[1] in his study of the coal deposits of Georgia speaks of these beds containing iron carbonate in the form of nodular concretions. The shales of the Lookout formation are perhaps more argillaceous and of greater thickness than those of the Walden sandstone. No attempt has been made to utilize the shales for clay products. Inaccessibility and difficulties of mining will be deterring factors in their development. Where not too sandy the shales of the coal measures will probably be found more plastic than those of the older formations since less metamorphism through folding and crumpling of the strata has taken place.

The following sections of the Lookout sandstone formation will illustrate the character of the beds and the relation of the shales to the sandstone, and the stratigraphic position of the shales.

Section of Lower Coal Measures Along The Durham and Chickamauga Railroad[2]

1	Massive sandstone and conglomerate (top of the Lookout sandstone)	150	feet
2	Thin-bedded sandstone	60	"
3	Sand shale	10	"
4	Black shale	15	"
5	Sandy shale	50	"
6	Gray shale	50	"
7	Thin-bedded sandstone	40	"
8	Shales	..	

1. Geol. Survey of Georgia, Bulletin No. 12, Coal Deposits of Ga., p. 19.
2. S. W. McCallie, Georgia Geol. Surv., Bulletin 12, Coal Deposits of Georgia, p. 45.

GENERAL VIEW AT THE CLAY MINES OF THE ATLANTA MINING AND CLAY COMPANY, TWIGGS COUNTY, GEORGIA.

Section of Pigeon Mountain Above Bronco[1]

1	Sandstones of variable character	10 feet
2	Sandy and ordinary shales	90 "
3	Yellow sandstone	10 "
4	Sandy shales, mostly concealed	10 "
5	Sandstones in thick, but with false bedding	155 "
6	Shales and sandy shales	260 "
7	Sandstones with some conglomerate in thick beds, dipping 5° to 10° westward	40 "

Bangor Limestone

The Bangor limestone formation consists principally of blue and gray, heavy-bedded limestone. Both the top and the base of the formation are shaly and it passes into the shales of the Coal Measures on the one hand and into the Fort Payne chert series on the other. Its thickness is given by Dr. C. W. Hayes as varying from 300 to 800 feet. It is of small distribution areally and is mainly confined to the flanks of Lookout, Sand and Pigeon mountains, while small isolated areas occur in White Oak, Rocky and Little Sand mountains. The formation may be largely concealed by talus and debris from the mountains.

Clays.—The formation weathers into deep red clays, which when sufficiently free from fragmental rocks may be used for building brick. The shale feature of the formation has not been closely investigated, but from what is known, the shales do not give promise of being of any especial value for clay products. There are no clay industries utilizing the clays of the formation.

Floyd Shales

The Floyd shale formation consists of shales, and thin-bedded limestones and sandstones. The shales are both argillaceous and calcareous and contain interbedded limestones and sandstones. The argillaceous shales are black,

1. J. W. Spencer, Georgia Geol. Surv., Palezonic Group, p. 137.

bluish-gray and umber colored; they are often very carbonaceous. The thickness of the formation is given by Dr. C. W. Hayes as 1,200 feet. It occupies an extensive area northwest of Rome, and forms small synclinal valleys in Taylor's Ridge and east of White Oak Mountain in Whitfield and Catoosa counties. Its distribution is shown on the map accompanying this report.

THE CLAY SHALES.—Some of the shales of the formation are suitable for the manufacture of clay products, but have up to the present remained undeveloped. The shales will generally be found less metamorphosed than those of the older Silurian and Cambrian formations. Tests on a sample of the Floyd shale from 1½ miles east of Ringgold are given in a subsequent part of this report. The greater part of the formation is inaccessible to railway lines, though the belt northwest of Rome is crossed by the Southern Railway, and the Western and Atlantic Railroad crosses the synclinal valley east of White Oak Mountain.

FORT PAYNE CHERT

The Fort Payne chert formation consists mainly of chert with small amounts of limestone, and reaches a thickness of 200 feet. It forms a thin band paralelling Lookout, Sand and Pigeon mountains, and forms ridges adjacent to the Floyd shale areas in Floyd, Walker, Whitfield and Catoosa counties. The areas underlain by it are easily recognized by the abundance of cherty material at the surface.

CLAYS.—The formation bears a highly siliceous fire clay of residual origin. This clay has not been developed in Georgia, but is being mined in the vicinity of Valley Head, Alabama, on the Alabama Great Southern Railroad, just across the Georgia-Alabama State line, and occurrences similar to that in Alabama will doubtless be found in Georgia. In Dade county, small deposits of halloysite occur near the base of the formation. Some of the deposits may be of value for adulterating and other purposes. Halloysite occurs near Rising Fawn and Trenton, and an occurrence was reported by Dr. J. W. Spencer[1] near Subligna in Floyd county.

DEVONIAN

The Devonian formation of northwest Georgia has been divided by Dr. C. W. Hayes into the Chattanooga shale, Armuchee chert, and Frog Mountain sandstone. The formation names are themselves explanatory of the character of the rock. The Devonian is generally inconspicuous, and of small areal distribution.

The Chattanooga shale is a black, highly carbonaceous shale which has been often mistaken for coal. The formation reaches a thickness of only about 10 feet. The lower part is a rather thick bedded, stony shale with an odor of petroleum and sulphur. The upper part bears a layer of phosphatic concretions and clay. The formation occurs only in the northwest part of the State and exists as a narrow band underlying the lower Carboniferous formations.

On account of its small areal distribution and its highly bituminous and stony character, it does not give any promise of being of importance for use in the manufacture of clay products. It has been used to a small extent as a filler for commercial fertilizers.

The following is an analysis[2] of the shale from near Estelle, Walker county:

Bituminous shale, Devonian, from Dug Gap, near Estelle, Walker county.

SiO_2	51.03
Al_2O_3	13.47
Fe_2O_3	8.06
MgO	1.15
CaO	.78
Na_2O	.41

1. Geol. Survey of Ga., The Paleozoic Group, p. 212.
2. Bull. 248, U. S. Geol. Surv., p. 343.

K_2O	3.16
H_2O	.81
P_2O_5	.31
S	7.29
Fixed carbon	13.11
Volatile hydrocarbons	3.32
	102.90
Less O=S	2.74
	100.16

Rockwood Formation

The Rockwood formation forms the uppermost division of the Silurian system. It consists of massive and thin bedded sandstones with thin beds of fossil shales. It also contains beds of hematitic or fossil iron ore which are of great commercial importance. The formation in Georgia varies in thickness from 600 to 1,500 feet. It is not of wide areal distribution; the strata are highly inclined, and form narrow ridges. It occurs in White Oak Mountain, Dick and Taylor ridges and other ridges and mountains in Floyd, Walker, Whitfield and Catoosa counties. It also forms narrow belts skirting Lookout and Pigeon mountains.

The clay shales of the formation may in some places be of considerable value for clay working purposes. The shales are brown or yellow in color, fine grained, fissile or minutely jointed. They may be of great thickness, but are interbedded with sandstones and very sandy shales. Where near the fossil iron ore bed, they are dark red and highly ferruginous. In their physical properties they have the same general disadvantage that nearly all of the shales of the Paleozoic area have, namely, low plasticity and strength, and are for this reason most suitable when somewhat decomposed by weathering. They are red burning, and burn to dense compact bodies at low temperatures. They contain only very small percentages of lime, and are free from pyrite, and carbonaceous material. Shales of the formation are accessible to the Chattanooga Southern and Alabama Great Southern Railroads.

Rockmart Slate

The Rockmart slate formation consists mainly of slates but also contains some limestone, shale and conglomerate. According to Hayes it has a thickness of 2,500-3,000 feet, and at the base consists of a great thickness of slates, which have resulted from the metamorphism of calcareous shales; the slates are overlain by a limestone conglomerate and this in turn by a series of shales and limestones with some sandstone and chert. In its distribution it is confined to the southern part of the Paleozoic area and to Polk county. The best exposures in the formation are seen in the vicinity of Rockmart.

The slates are minutely jointed, and through pressure a slaty cleavage has been developed, and the original bedding of the shale has been destroyed. The rocks have a strong dip to the southeast and through extreme metamorphism are contorted and crumpled. The slates are essentially the same as shales in composition, but by metamorphism have a stony character and have lost their property of plasticity. By weathering, the slates change into brown or yellow material and then show some plasticity. The so-called Caen stone at Rockmart is a weathered product of the slates. The fire and terra cotta clays at Aragon and Rockmart are due to a weathering and leaching of metamorphosed shales of this formation.

Weathered shales of the formation together with residual clay resulting from them are being used in the manufacture of Portland cement and common brick at Rockmart.

The following is an analysis of the slate at Rockmart[1]:

Silica, SiO_2	58.20
Alumina, Al_2O_3	18.83
Iron oxide, Fe_2O_3	5.78
Lime, CaO	4.35
Magnesia, MgO	3.51
Alkalies, (K_2O, Na_2O)	3.20
Sulphur, S	.49
Carbon, C	.82
Carbon dioxide, CO_2	.60
Water	4.07
Total	99.85

Chicamauga Limestone

The Chicamauga limestone formation consists of thinly and rather evenly bedded, bluish, gray, dove colored and earthy limestone. It has a rather wide distribution in the Paleozoic area and according to Hayes[2] reaches a thickness of 1,800 feet on the western side of Chattoogata Mountain.

The following are analyses of limestone of the formation:

	I	II
H_2O	.06	.04
Loss on ignition	42.27	37.96
SiO_2	2.50	14.22
Al_2O_3 } Fe_2O_3 }	.64	1.13
CaO	52.50	33.74
MgO	1.42	9.66
Undetermined	.61	3.25
Total	100.00	100.00

I. and II. Limestones from Davitte, Polk county, Dr. Edgar Everhart, analyst.

The limestones of the formation are used for lime making, building stone and in the manufacture of Portland cement.

In weathering, the limestone produces a red, or bluish and yellow residual clay. The residual clays of the formation,

1. U. S. Geol. Surv., 18th ann. pt. 5.
2. U. S. Geol. Surv., Ringgold Folio.

where sufficiently free from undecomposed rock fragments, may be used for clay products, but no attempt has been made to utilize them for this purpose. In the upper part of the formation a stiff, greenish residual clay has been noted and is mentioned in subsequent parts of this report.

Knox Dolomite

The Knox dolomite is an extensive and uniform formation and consists of 3,000 to 5,000 feet of heavy bedded bluish and gray magnesian limestones. It forms low, rounded ridges, and a characteristic of the formation is the great abundance of nodules and layers of chert which it contains. Economically, it is a very important terrane on account of the large number of economic mineral products associated with it—bauxite, iron ores, manganese, road building material, clays and limestone for building and lime making purposes.

It forms a broad belt in the northern part of Polk, the eastern part of Floyd and western part of Bartow counties, while cherty ridges of the formation having a northeast-southwest trend and from 1 to 5 miles wide occur in Walker, Chattooga, Catoosa, Gordon, Whitfield and Murray counties.

The formation is extensively weathered, weathering having taken place to a depth of 100 feet or more, and bears some valuable residual clays. The residual clays, however, are highly siliceous, cherty, since they have resulted from the carrying away in solution of the limestone, and are themselves the clay originally contained in the limestones and which is left as a residuum after the removal of the limestone. There are extensive pockets of white or light colored highly siliceous clays which are of value for fire clays. A pocket of this clay is now being utilized at Mission Ridge in Walker county. The formation also produces a red residual clay, but this is of little value to the clay worker on account of the great quantity of chert fragments that it contains. Other valuable clays associated with the formation occur in connection with the bauxite deposits of northwest Georgia and the iron ores in the vicinity of Cedartown. These clays are discussed in detail in subsequent parts of this report.

CAMBRIAN

Conasauga Shale

The Conasauga shale formation is of Middle Cambrian age and consists mainly of fine clay shales, which contain intercalated beds of limestone, while the formation is also siliceous and may contain sandstone and very sandy shales. It has been found quite variable in character in closely adjoining regions. Its thickness is variable, but always great and reaches 4,000 feet. The formation is of wide distribution and underlies an extensive area in the Coosa and Conasauga valleys. Its areal distribution is shown on the sketch map, accompanying this report. The formation is everywhere highly folded and faulted, and the shales are crumpled and contorted. Near the Cartersville fault or the contact with the crystalline schists of the Crystalline area, the shales may be highly metamorphosed and schistose or slaty in character.

Weathering has been extensive throughout the Conasauga terrane and the formation is obscured by red or yellow clay soils. Near the surface the shales are minutely jointed and break down into small chips or angular fragments.

The shales of the formation, though having some very objectionable properties, are of value for brick purposes. They are generally lacking in plasticity and strength, but burn to dense bodies at low temperatures. They are generally fine in texture, and free from carbonaceous matter and iron sulphide.

The following analyses will indicate the chemical character of the shales:

	I	II	III	IV
SiO_2	54.31	57.31	55.330	52.82
Moisture	2.00	1.02	0.420	0.23
Ignition	6.59	5.28	4.712	7.00
SiO_2 (sand)	19.87	32.88	28.000	.....
Al_2O_3	23.04	21.52	22.006	26.17
Fe_2O_3	6.63	7.65	5.950	9.46
MnO	0.12	0.04	trace	.....
CaO	0.28	0.22	0.490	trace
MgO	1.40	2.47	1.568	1.08
Na_2O	.08	1.29	.821	0.20
K_2O	4.32	2.70	7.128	2.71
TiO_2	.90	1.10	1.104	.....
S	.06	.....	0.068	.....
P_2O_5	.04	.....	.....	.....
Total	99.77	100.60	99.597	99.67

I. Shale from Lafayette, Edgar Everhart, analyst.
II. Shale from Chatsworth, Edgar Everhart, analyst.
III. Shale from Rome, Edgar Everhart, analyst.
IV. Shale from Cartersville, J. M. McCandless, analyst.

The shales are within themselves non-calcareous, though the Conasauga formation does contain limestones, and is described as calcareous. Potash and iron are the chief fluxing impurities.

There are only two localities where the shales of the Conasauga formation are used for brick making, namely, Calhoun and Rome. Residual clay from this formation is utilized for common brick at Adairsville.

Rome Formation

Underlying the Conasauga formation, there is a great thickness of sandstone and sandy shales which have been given the name, Rome formation. The formation reaches a thickness of 3,000 to 4,000 feet. It consists of red, purple and variegated thin bedded sandstones and sandy shales. As mapped in the Rome folio of the United States Geological Survey it occupies a narrow belt extending from Cave Spring in a northeast direction through Rome and lying to the west of the Southern Railway to Plainville and Oostanaula. It also forms a north-south belt, in which are located Catoosa Springs and Tunnel Hill, in Catoosa and Whitfield counties, and extends into Walker county.

On account of the very sandy and stony character of the shales of the formation, they are of no value for clay working purposes.

Beaver Limestone

The Beaver limestone formation is of Lower Cambrian age, and is composed of gray, magnesian limestone 800 to 1,200 feet in thickness. It is known to occupy a small area at the base of Indian Mountain in Polk county and in the vicinity of Cartersville. It is deeply weathered and produces a red clay, which is, however, usually filled with fragments of quartzite derived from the Weisner quartzite formation.

Weisner Quartzite

The Weisner quartzite is regarded as the lowermost Cambrian of the Paleozoic area. It forms Indian Mountain, and occurs in a belt about 15 miles in length in contact with the crystalline schists of the metamorphic belt in the vicinity of Cartersville. It is composed mainly of a great thickness of quartzite with some sandstone and sandy shales. The formation does not produce any clays of importance.

IGNEOUS AND METAMORPHIC ROCKS

Forming the Crystalline area of the State, is a great complex of igneous and metamorphic rocks differing markedly from the sediments of the Coastal Plain and of the Paleozoic area. The Crystalline area, which includes the Piedmont Plateau and the Blue Ridge, comprises the entire northern part of the State, with the exception of ten northwest counties, and forms an area of about 18,000 square miles. The rocks of this area are intrusive and eruptive granites, diorites, diabases and basic magnesian rocks, together with ancient, highly metamorphosed sandstones, limestones and shales. The whole region has undergone intense dynamic movements, and the rocks have been profoundly altered from their original condition. The sediments have been so metamorphosed that little trace of their original texture remains. Fringing the Paleozoic area there is a belt of mica schists, which were probably originally sediments. The igneous rocks have also often been converted into gneisses and schists. The rocks have been intensely folded, crumpled and faulted and extensively eroded.

The non-decomposed rocks of the Crystalline area do not furnish material suitable for clay products, but by the agency of weathering some valuable clays have been formed. The rocks of this region have been subjected to atmospheric agencies for enormous lapses of time, and by the action of rain, frost, wind, and by the chemical action of gases in the atmosphere, and by plants and animals, the rocks have decomposed to great depths. The feldspathic and other aluminous minerals have formed clay, and the more stable minerals, as quartz, form mechanical detritus.

As a result of decay from weathering of highly feldspathic granites and pegmatites, deposits of residual kaolin have been formed. Throughout the Piedmont region the rocks have weathered into a conspicuous red clay soil. The residual clays resulting from rock decomposition have been taken into suspension by rainwater and transported to the foot of slopes and thence into small ravines or branches and into larger streams where they are partly dropped, forming alluvial clay deposits. Residual kaolin is mined at only one locality in the Crystalline area, but occurrences have been noted at a number of other localities. Alluvial and colluvial deposits of clay in the Crystalline belt furnish some excellent material for common brick, earthenware and terra cotta. The metamorphic schists and their weathered product are being used at two localities for clay products. The residual clays of the region are unimportant within themselves, but are used in mixtures with other clays.

CLAYS DERIVED FROM THE GRANITES.—The main granite areas lie in the Piedmont Plateau, but throughout the entire Crystalline area, there are small intrusive masses, sheets, veins and pockets and pegmatite dikes. The principal granite areas are: 1. The Stone Mountain-Lithonia area, which extends southwestward through Campbell county, and underlies a great part of Coweta, Troup and Meriwether counties; 2. The Elberton-Lexington area; 3. An area stretching from Washington through Greensboro to Eatonton; 4. A narrow belt extending from Milledgeville along the Fall Line almost to the Savannah River. In addition, during field work the writer observed numerous small masses, dikes and sheets in Paulding, Cherokee, Pickens, Towns, Union, White and Rabun counties.

The granites are composed essentially of quartz, feldspar, mica (muscovite and biotite) while smaller amounts of accessory minerals as magnetite, apatite, zircon, chlorite and pyrite occur. The decomposition of pegmatite or highly feldspathic granites produces residual kaolin deposits. Such deposits likely to be in commercial quantity were noted at Union Point, Jasper, and Dallas. The residual clays derived from the granites are unimportant since they contain such a large per centage of coarse sand and rock fragments that they are unsuited for brick or other purposes. The clay from the residual deposits, however, is washed into small valleys and light colored plastic clay deposits result. A typical deposit of this type is that on the property of Chas. T. Moses, near Turin, Coweta county. This is subsequently described. The follow-

CLAY PIT OF ATLANTA MINING AND CLAY COMPANY, DRY BRANCH, GEORGIA.

ing is an analysis by Dr. T. L. Watson[1], of a red residual clay derived from biotite granite, near Greenville:

SiO_2	51.29
Al_2O_3	29.69
Fe_2O_3	6.33
CaO	.07
MgO	0.14
Na_2O	1.12
K_2O	1.50
Ignition	10.36
Total	100.50

METAMORPHOSED SEDIMENTS.—Metamorphosed sediments are being utilized at two points in the Crystalline area for clay products. Near Bolton, in Fulton county, they are used in the manufacture of building brick, and at Belair, in Richmond county, they are mined and utilized for sewerpipe and paving blocks, in mixtures with other clays. The rock at the two localities mentioned was probably originally shale, but it has been so completely altered that but little trace of its original condition remains. Fringing the Paleozoic area there is a belt of contorted and highly folded hydromica schists and slates, evidently derived from sedimentary rocks. They are within themselves non-plastic and hence of no value to the clay worker. They are intimately cut by quartz veins and the soil resulting from them is full of quartz fragments. There are areas of quartzites, limestones and phyllites throughout the Crystalline belt, but these do not contain clays of economic value.

BASIC ERUPTIVES AND SCHISTS.—The basic eruptives, hornblendites, and diabases yield upon weathering a deep red clay soil. This clay is of but small value for clay products. Mica-schists of obscure origin underlie extensive areas and produce a stiff red clay, which would be serviceable for brick purposes were it not for the great abundance of coarse quartz fragments which it contains.

1. Ga. Geol. Surv., Bulletin 9-A, p. 315.

THE KAOLINS AND FIRE CLAYS OF GEORGIA

Introductory Statement.—Georgia may be divided geologically and physiographically into three main divisions—the Paleozoic area, the Crystalline belt, including the Piedmont Plateau and the Blue Ridge, and the Coastal Plain. The Paleozoic area is a region of folded Paleozoic sediments, limestones, sandstone and shales, occupying the northwestern corner of the State and forming an area of approximately 3,500 square miles.

The Crystalline belt embraces the north, northeast and north-central parts of the State, and is a region of granites, gneisses, schists, basic eruptives and highly metamorphosed, ancient sediments.

The Coastal Plain embraces all that part of the State lying south of Augusta, Macon and Columbus, or the Fall Line. It is underlain by Cretaceous, Tertiary and Pleistocene deposits.

All three of the main geological divisions of the State are known to contain valuable deposits of kaolins and fire clays, and the clay deposits of these three divisions shall be considered separately, partly for convenience of description, and partly because the deposits of the three regions are unlike in nature and origin. The clays of the Coastal Plain are the most valuable commercially, and the description of these clays will be taken up first.

As above mentioned, the strata of the Coastal Plain are of Cretaceous, Tertiary, and Pleistocene age. These formations are of sedimentary origin, and consist mainly of sands, clays, marls, and limestones, the sand and clay greatly predominating. The beds lie upon the eroded surface of the ancient rocks of the Crystalline belt, and have a gentle slope southeastward. The line of contact between these comparatively recent and soft formations, and the ancient crystalline rocks of the Piedmont Plateau is known as the Fall Line, because of the falls and rapids in the streams, which flow from the Piedmont region, at this line of contact.

The falls result from the difference in character of the geological formations, the crystalline rocks being hard and difficult of erosion, while the Coastal Plain formations consist of loose and unconsolidated sand and clay, easily eroded. The Fall Line extends in a northeast-southwest direction entirely across the State, and is marked by the cities of Augusta, Milledgeville, Macon and Columbus.

It is to be remarked here that the kaolins of the Coastal Plain are of sedimentary origin, and thus differ from much of the kaolin on the market, which is residual in origin, and which is derived chiefly from the weathering of pegmatite granite. No objection can be made to the term kaolin being applied to these sedimentary clays, inasmuch as they are white burning, and approach the chemical composition of kaolinite. They do differ, however, in their physical properties, being much more plastic and generally having higher air dried strength than the residual kaolins. The suggestion[1] that they be termed *plastic kaolin* to distinguish them from residual kaolins, is a good one.

1. H. Ries, Clays, Occurrence, Properties and Uses, p. 165.

CHAPTER V

CRETACEOUS KAOLINS AND FIRE CLAYS

The most extensive and purest clays are found in the northern part of the Coastal Plain, and are known as the Fall Line belt of white clays. They occur in the Cretaceous system of rocks, and are confined mainly to the Tuscaloosa (Potomac) formation. The Tuscaloosa is a belt of cross-bedded sand, gravel and white clay, lying in contact with the Crystalline rocks, and extending the entire width of the State. Deposits of high-grade clays have also been discovered in the Tertiary formations to the south of the Fall Line. The general geological features of the Coastal Plain formations have been discussed in previous chapters, and the discussion will not be repeated here. The importance, however, of knowledge of the geological structure, occurrence, and origin of the clay beds can hardly be overestimated in carrying on intelligent prospecting for and mining of the clays.

The detailed description of the Fall Line or Cretaceous clays will be taken up first, and will be followed by a discussion of the less extensive Tertiary clays.

TWIGGS COUNTY

This county is about the geographical center of the Fall Line belt of clays. It contains the most valuable and perhaps the most extensive beds of white clays to be found in the State. The mining of clays is actively carried on at one locality, but there is not a clay manufacturing industry in the county, and its clay resources have hardly been touched.

Dry Branch Region

Dry Branch is located on the Macon, Dublin and Savannah Railroad, 9 miles southeast of the city of Macon. Within the vicinity of this station four companies are actively engaged in the mining and marketing of high-grade clays. The clays mined are kaolins, suitable for pottery and paper trade, and high-grade fire and sagger clays.

The Georgia Kaolin Company

This company operates a mine two miles southeast of Dry Branch. This is the first of the present companies to engage in mining and marketing high-grade clays. Much credit is due to the gentlemen forming this company for their faith in the value of the clay and their persistence in compelling manufacturers to recognize its merits.

The clay mined occurs in one massive bed, which, in the pit that was being worked during 1907, attained a thickness of 20 feet. This entire thickness is probably as much as 85 per cent. pure clay, and in places the clay occurs in minable quantities as high as 98 per cent. pure without washing. The clay bed is overlain by variegated, massive sands and impure clays, and its base is seen to gradate into a micaceous, kaolinic, quartz sand. Prospecting at other points removed from the clay pit, has revealed a great thickness of clay, which is certainly a continuation of the bed that is being worked, and the quantity of clay available is, without doubt, sufficient to justify extensive mining operations. The purity of the clay at points where it is entirely concealed, can not be foretold with accuracy, though there is no geological evidence to indicate that it may be expected to show any greater amount of impurities than at the pit.

The following is the vertical section exposed at the pit which was being worked at the time of my visit to the property:

		Feet
1	Massive, fine, red sand, reaching a maximum of 100 feet	100
2	Greenish and drab, stratified clay	15
3	Massive, fine, yellow sand	12
4	Soft limestone and limestone and kaolin conglomerate	4
5	Massive, jointed and slickensided kaolin	20

The clay, as it appears in the bed and in the moist condition, is a drab or cream color, but becomes white when dry. The bed is jointed throughout, and presents slickensided surfaces along the joint planes. The clay in the upper part of the bed is a semi-hard to a flint clay, and may be stained slightly along the joint planes by manganese and iron oxides. The manganese is rarely in appreciable quantity and occurs as a very thin coating or stain, or is often in the form of fern-like dendrites. In the upper part of the bed there are also curious "fingers" and cylinders of sand, penetrating the white clay. This is a phenomenon observed nowhere else in the Dry Branch region, and is difficult of explanation. The "fingers" of sand are usually vertical or oblique, and are not more than one or two inches in diameter. The sand in them is a yellow, coarse quartz, clayey sand, which may be calcareous, and has been observed to contain poorly preserved fossil remains. These "fingers" are not large nor very abundant, but detract from the value of the clay where they occur and the upper part of the bed is thrown away as waste, or sold as fire clay and sagger clay. They are confined to the upper two or three feet of the bed, and are probably purely local and may not be found at all in future work.

The lower part of the bed is a soft, white, gritless kaolin which is pure enough to place on the market without preliminary washing.

The material overlying the clay bed, or the overburden, consists of loose, red and yellow sands, soft, greenish and drab clays, and local, thin beds of soft limestone. The sand and clay are unconsolidated, and can be easily removed by scrapers and steam shovels. The limestone is very soft, and the beds are not persistent. In plate X, a limestone bed may be seen lying unconformably upon the clay bed. The base of the bed here is a curious limestone and kaolin conglomerate. In an old pit a few yards to the north, the limestone bed is not seen, and is replaced by loose sand. The amount of overburden at present, is 30 feet. This thickness will gradually increase to a maximum of more than 100 feet, should the clay bed be worked back to the crest of the hill.

The clay bed outcrops at the bases of the hills and is almost horizontal, having only a very small dip to the southward. This fact will be found of great importance in locating the clay bed and in estimating the amount of overburden to be removed. Variations in the thickness of the bed may occur, which are due to irregularities of deposition and to erosion of the clay bed before the deposition of the overlying strata. A structural feature which has an economic application, is the jointing. The joints have no definite system or fixed direction, and may be oblique, vertical or horizontal, and the bed may be minutely jointed or there may be only large cracks at wide intervals. The jointing has the appearance of being due to shrinkage of the clay mass, and not to orogenic movements. Some movement has taken place along the joint planes, and slickensided surfaces have been caused by the gliding of one mass of clay over another. During rainy weather water penetrates these joints, and acting as a lubricant along the already slick surfaces, masses of clay slip off from the clay face by gravitation. The jointing has also affected the purity of the clay, since waters filtering through the overlying iron stained sands, have taken iron oxide into suspension and deposited it in the joint cracks of the underlying clay beds.

The clay is mined from open pits. The overburden is removed from the top of the bed and 15 or 20 feet back from the clay face or breast, to avoid the possibility of its caving and filling the pit. The clay is then mined by hand with picks and shovels. The jointing is taken advantage of, and long wooden or steel stakes are driven into the top of the bed near the edge of the clay breast, and large chunks of clay thus pried off. The clay is taken from the pit in chunks six inches to two feet in length, and hauled in cars by a wire cable to the air drying sheds.

The Georgia Kaolin Company mines and sells pottery and paper kaolins and fire and sagger clays, nearly all of which go to Northern markets. None of the clay receives mechanical treatment other than crushing, but the company is now making preparations to install a clay washing plant, the object being to secure uniformity of product, and to avoid waste in mining.

LABORATORY TESTS.—The following is a chemical analysis of the kaolin which is mined and shipped for pottery use and to paper manufacturers. The sample was selected from the pit and is believed to represent the average as near as possible:

Analysis of a Kaolin From the Pit of the Georgia Kaolin Company

Moisture at 100° C.	1.22
Loss on ignition, water	13.46
Silica, SiO_2	44.76
Alumina, Al_2O_3	38.41
Iron oxide, Fe_2O_3	.63
Lime, CaO	.20
Magnesia, MgO	.09
Soda, Na_2O	.09
Potash, K_2O	.35
Titanium dioxide, TiO_2	1.37
Sulphur, S	none
Phosphorus pentoxide, P_2O_5	none
	100.58

Rational analysis:

Quartz	none	Sand	.68
Feldspar	.68		
Clay substance			99.32
			100.00

The amount of water required to work up the clay to its maximum plasticity, was 44 per cent., based upon the weight of the dry clay. The clay, however, will develop good working plasticity with a much smaller percentage of water. The air shrinkage was low, averaging 4 per cent.; the tensile strength of the air dried briquettes averaged 28 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
1	3.9%	white	soft
4	7.9%	white	....
5	8.3%	white	....
8	12.0%	white	shows checking
11	......	white	steel hard, not vitrified

At cone 8, shows slight checking or cracking, is white, but shows minute, dark specks. At cone 1 it was pure white, but very soft. The water absorption was high, owing to the cracks which developed in burning.

The clay is a high-grade fire clay in point of refractoriness, having a fusing point above cone 33, 3,254° F.

Examined under the microscope, the clay consisted principally of translucent and milky aggregates of a silicate of alumina, which is the clay substance, very fine flakes of muscovite mica, and rarely an angular particle of quartz. There are also minute particles of black minerals, which have not been identified positively, but are most probably particles of hornblende or augite, or possibly ilmenite. Yellow iron oxide was observed to form a coating over the clay particles and is in a very finely divided state. Microscopic examination does not reveal a large percentage of sandy impurities, yet the quartz and black minerals could be largely eliminated by washing and the quality of the clay improved.

The clay shows good slaking properties. A one-inch cube after being thoroughly dried, was placed in a beaker of clear water, containing 250 CC. The clay slaked completely in 6 minutes, to a pulverulent mass. The water was thoroughly stirred and was observed to be milky, 48 hours after the stirring, showing the minuteness of the clay particles and their quality of remaining in suspension in water.

A second sample of clay from this property was tested to determine its air dried strength. It came from near the bottom of the clay bed and was slightly darker in color than the above sample. The clay shows good plasticity, and its average strength was 46 pounds per square inch. It is not known in what quantity this clay occurs. However, it is certain that clays from different parts of the bed will show variations in air dried strength.

The clay mined by the Georgia Kaolin Company is used in the manufacture of white ware pottery, electrical porcelain and sanitary ware. The combination of white burning qualities and a good air dried strength, together with excellent plasticity, makes it a very desirable clay. It is also extensively used by paper manufacturers as a filler for paper. Saggar clay from these mines is shipped as far north as Canada.

Atlanta Mining and Clay Company

This company operates two pits on the Macon, Dublin & Savannah Railroad, 2 miles south of Dry Branch. The occurrence of the clay here is quite similar to that at the mines of the Georgia Kaolin Company, just described.

A thickness of 25 feet of clay is known to occur, but at present only 8 to 15 feet are mined. The clay bed is for the most part, a soft, plastic, white clay. The clay is massive and occurs in a single bed; it is jointed and shows slickensided surfaces, but presents no definite system of jointing, and is slightly stained by iron and manganese oxides along the joint planes. The bed shows variations in thickness, due either to irregularities of deposition or to erosion. The strata here are almost horizontal, and are but little disturbed from their original positions. The clays in the two pits, about 200 yards apart, are parts of the same bed. The clay bed becomes micaceous at the bottom, and is underlain by white sand and gravel.

The overburden consists of unconsolidated sand and impure clays. The soft limestone seen in the overburden at the pit of the Georgia Kaolin Company does not occur here, although the strata in both instances occupy the same geological position, and the two places are only about 2 miles apart. The overburden will increase as the clay is worked back into the hill, and will reach a maximum of 100 feet, this being the height of the hills above the small valley in which the clay bed outcrops and in which the pits are located. The following section made in pit No. 2, shows the nature of the overburden:

Overburden at Pit No. 2, Atlanta Mining and Clay Company

1	Fine, loose, red sand	3 feet
2	Greenish, laminated, tough clay	4 "
3	Very fine-grained, red sand	5 "
4	Dark clay layer	1 "
5	Red, micaceous sand, containing smutty particles of a manganese oxide	4 "
6	Yellow, ocherous sand	3 "
7	Sand, containing white clay pebbles	3 "
8	White, kaolinic sand	8 "
9	White kaolin	12 "

The section in pit No. 1 is as follows:

1	Gray sand	4 feet
2	Drab-colored, thin-layered clay	3 "
3	Yellow clay and sand	2 "
4	Vermillion colored sand	5 "
5	Yellow, ocherous sand	8 "
6	Greenish, sticky clay sand	5 "
7	White clay	15 "

It will be observed that the overburden at each of the two pits is composed entirely of soft rock, and that the two sections show no material difference. The study of the above sections also affords a ready explanation of the caving of the overburden and the filling of the pits with water during rainy weather. The overburden is for the greater part loose sand, and rainwater readily filters through it, and a gradual slipping from gravity results, and when the water reaches the impervious white clay bed, it issues as springs and flows into the clay pit.

Mining is carried on in open pits, and the overburden is removed by a steam shovel. The clay is mined by hand and hauled in large chunks to long air drying sheds. Pottery, paper and fire clays are mined.

The following is an analysis of the paper and pottery clay from pit No. 1:

Analysis of Kaolin From Pit No. 1, Atlanta Mining and Clay Company

Moisture at 100° C.	10.72
Loss on ignition, water	12.39
Silica, SiO_2	40.28
Alumina, Al_2O_3	34.72
Iron oxide, Fe_2O_3	.84
Manganous oxide, MnO	trace
Lime, CaO	.05
Magnesia, MgO	.04
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide, TiO_2	1.15
Total	100.19

The clay contains:

Quartz	1.57	Sand	1.57
Feldspar	trace		
Clay substance			98.43
Total			100.00

This clay is a cream color when moist, becoming white when dry. When moist, it has an unctuous or greasy feel, and cuts like a piece of cheese. It is almost entirely free from grit, none being detected by the sense of touch. Under the microscope, angular quartz particles may be recognized, and the clay particles may contain a yellow coating of iron oxide. Minute flakes of muscovite mica probably occur in the clay, but are not abundant, and are difficult to distinguish from the clay.

PHYSICAL TESTS.—When worked up with 31 per cent. of water, the clay developed good plasticity, and showed an average air shrinkage of 5.4 per cent. The tensile strength of the air dried clay was low, being 16 pounds per square inch. It slakes readily in water into a pulverulent mass.

Burning Tests.

Cone	Fire-Shrinkage	Color
4	6.7%	white
9	14.3%	white

At cone 4, 2,210° F, the clay burned to a pure chalky white but the bricklet cracked badly in the burning. At cone 9, 2,350° F., it burned white, steel hard, and showed slight cracking. Vitrification takes place only at very high temperatures. In point of refractoriness, it is a fire clay of the highest grade, being unfused at cone 33, 3,254° F.

The foregoing tests are remarkable inasmuch as the clay has received no mechanical washing or purification. This clay should be suitable for use in the manufacture of chinaware, sanitary ware, encaustic tiling, etc., and also for terra cotta, ornamental building brick, and high grade fire brick.

A white clay sample from No. 2 pit gave the following analysis:

Moisture at 100° C	.93
Loss on ignition, water	13.73
Silica, SiO_2	44.97
Alumina, Al_2O_3	38.51
Iron oxide, Fe_2O_3	.51
Lime, CaO	.00
Magnesia, MgO	.16
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide, TiO_2	1.36
	100.17

The kaolin contains:

Feldspar	.00	Sand	.33..
Quartz	.33		
Clay substance			99.67
Total			100.00

The purity of this clay is remarkable, and so far as the writer is aware, no other kaolin in the United States, the analysis of which has been published, equals it in purity. The common fluxing impurities amount to only .67 per cent. The presence of the .16 per cent of magnesia, is rather difficult of explanation, but may have been derived from mica. The high per cent. of TiO_2 affords evidence that the titanium is in chemical combination with the aluminum silicate or clay, and does not exist as a separate mineral particle.

Of course it is not to be supposed that the entire thickness of the bed will maintain such remarkable purity. The top of the bed which is in contact with the overlying iron bearing sands, is more or less stained, and throughout the bed there are yellowish segregations of limonite. However, by proper selection, a great quantity of kaolin, approaching in purity the above sample, can be obtained.

PHYSICAL TESTS.—With 38 per cent. of water, the clay was very plastic, and showed an average air shrinkage of 4.6 per cent. The average tensile strength of six air dried briquettes was 20 pounds per square inch. The clay is soft and slakes readily in water, but does not seem to remain in suspension for any length of time.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	5.4%	white
9	9.7%	white

At cone 4, pure white, without cracking. At cone 9, pure white, very slight cracking, dense body, steel hard, and white under a clear glaze.

The clay is highly refractory, and becomes vitreous at cone 33.

This clay has been proven very suitable for white ware pottery.

CLAY SAMPLE No. 3.—In grading for a railroad spur track, a bed of white clay was encountered, a continuation of the bed exposed in pits No. 1 and No. 2. A chemical analysis of a selected sample from this bed shows:

Moisture at 100° C.	.87
Loss on ignition, water	13.48
Silica, SiO_2	45.15
Alumina, Al_2O_3	38.10
Iron oxide, Fe_2O_3	.80
Lime, CaO	.00
Magnesia, MgO	.06
Soda, Na_2O	.02
Potash, K_2O	.05
Titanium dioxide, TiO_2	1.38
Total	99.91

The kaolin contains:

Feldspar	.00	Sand	.74
Quartz	.74		
Clay substance			99.26
Total			100.00

The quantity of this clay available, has not been determined.

This clay is pure white, very fine grained and free from grit, and is much harder than the two clays just described. It is brittle when dry, breaks with a conchoidal fracture, and has good plasticity, notwithstanding a slightly "mealy" character. It has an air shrinkage of 4 per cent. and an average tensile strength of 47 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
3	4.6%	white
9	14.3%	faint cream
13	14.8%	bluish-white or gray

At cone 3, soft and porous. At cone 9, it showed a faint cream tinge and cracked badly. At cone 13, steel hard, but cracked badly.

A laboratory test of a pottery mixture, in which clay No. 3 and No. 2 were employed, was made by the writer. The mixture consisted of:

No. 3 clay	40%
No. 2 clay	25%
Spar	25%
Flint	10%

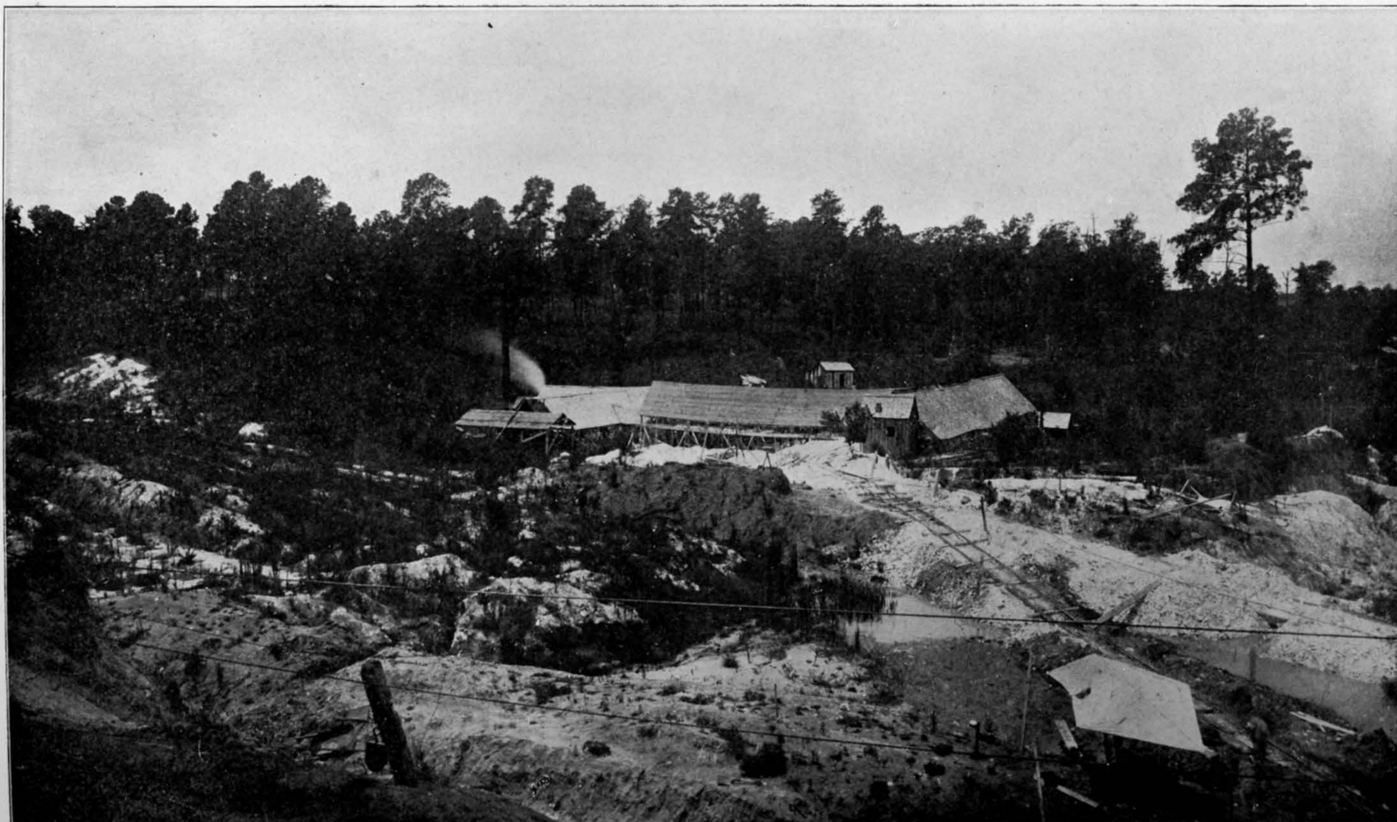
The mixture was quite plastic and showed a tensile strength of 30 pounds per square inch. The air shrinkage was 3.7 per cent. and no cracking was observed in drying. A sample was burned in a muffle to cone 9. The burned bricklet was semi-vitreous, tough, and burned white with only a slight amount of checking.

In the above mixture, using the exact percentages given, no pretensions are made that it would be successful in practice. It is intended merely as a suggestion, that a good porcelain body can be made at the mines without the importation of any other clays. It is believed that a successful pottery mixture might be only a matter of experimenting by an intelligent potter. On account of the clays vitrifying only at very high temperatures, a large per cent. of fluxing material will be necessary.

Physical Tests on Fire Clay from the Pits of the Atlanta Mining and Clay Company

This clay is composed mainly of the top parts of the beds and of the clay which is too impure to be of value for pottery or for the paper trade. It contains more sandy impurities than the selected clays.

When made up into a good working plasticity, it showed an average air shrinkage of 3.8 per cent., and a tensile strength, 140 pounds per square inch.



GENERAL VIEW AT THE MINES OF THE GEORGIA KAOLIN COMPANY, TWIGGS COUNTY, GEORGIA.

Burning Tests

Cone	Fire-Shrinkage	Color
1	6.1%	dull white
4	6.3%	dull white
14	9.4%	light buff

At cones 1 and 4 dense bodies, without cracking.

This should be an excellent clay for terra cotta and offers opportunities for white or buff ornamental building brick. The clay has good bonding power and will retain 50 per cent. of non-plastic material and preserve its high strength.

PIT OF THE MACON MINING COMPANY.—This pit is located 1½ miles south of Dry Branch and was formerly known as the Payne and Nelson Clay Pit. The property is now owned by the Atlanta Mining and Clay Company. No mining has been done here since 1903. The clay bed at the time of my visit was largely covered by debris, but 8 feet of clay was exposed. The clay appears to be excellent in quality, and free from iron stains, except at the top. The clay is white, free from any large amount of grit, soft, and has an unctuous or soapy feel. Near the top of the bed some of the clay was observed to be semi-hard and broke with an angular fracture. The bed was overlain by 20 to 30 feet of unconsolidated Tertiary sand and clay. Increase of overburden and a probable thinning of the bed were most likely the causes of abandonment. The clay is reported to have been a high grade paper clay.

This property was examined by Dr. G. E. Ladd[1] in 1898, who gives the following analysis of the clay:

1. Bulletin 6-A, Geol. Surv. Ga., p. 132.

Moisture	1.91
Combined water	13.39
Combined silica	43.08
Free silica, or sand	1.94
Alumina	40.63
Ferric oxide	1.01
Lime	.16
Magnesia	.00
Potash	.27
Soda	trace
	100.48
Clay base	97.00
Fluxing impurities	1.44

The high percentage of alumina is due to the fact that TiO_2 is included. It is reported to have burned white to pinkish, and to crackle in the burning. The tensile strength was given as 12 to 15 pounds per square inch, and its fusing point between Seger cones 35 and 36.

The bed here is in the same geological position as the beds just described at the pits of the Atlanta Mining and Clay Company, and the Georgia Kaolin Company. The overburden is similar, and the kaolin itself, does not differ materially.

American Clay Company

The pit of the American Clay Company is located on the Macon, Dublin and Savannah Railroad, 1½ miles southeast of Dry Branch. The clay is a soft, iron stained kaolin, and is sold entirely to paper manufacturers.

The clay bed is known to attain a thickness of 18 feet, the upper 10 feet of which is stained more or less yellow by iron oxide, while the lower part is a soft, gray, micaceous clay. The condition of the clay bed here, as elsewhere in the Dry Branch region, is likely to present variations, and a description can not be permanently applicable in its details. While it is characteristic that the clay beds of this region present variations in thickness, there is not much likelihood of abrupt terminations of thick beds; and there can be no doubt that there is an enormous quantity of clay available. The clay here is a continuation of the clay stratum exposed in the pits of the Georgia Kaolin Company, and the Atlanta Mining and Clay Company.

At the time of my examination, the clay differed notably in two respects from the clay at other points in the Dry Branch region. The whole thickness here is remarkably soft and friable, whereas at other localities there have been hard and even flint clays occurring. Secondly, the amount of iron oxide staining, is greater, and the staining is not entirely confined to the jointing, but may permeate the mass of the clay to a greater extent than observed at other mines.

The great amount of staining necessitates a careful selection of the clay, a great deal more "culling" and a consequent increased waste. As a result of the iron oxide, the clay is a cream color to a light yellow when moist, but it is a surprisingly lighter color when dry.

The amount of overburden in the present pit, is from 20 to 30 feet, and will reach a maximum of about 80 feet, if the clay bed maintains its thickness and is worked back a distance equal to the distance to the top of the ridge. The overburden consists of unconsolidated sand and clay, and its removal presents no special difficulties, except for its caving during rainy weather.

The overburden contains a peculiar occurrence of white clay. From four to twelve feet above the top of the main clay stratum, there is a layer of pisolitic and concretionary white clay, closely resembling bauxite. The layer is from six inches to three feet in thickness, and may grade into a kaolinic sand. So unusual was the form of the clay and so closely did it bear a resemblance to bauxite (aluminum ore), that a chemical analysis was made to determine its composition. The analysis, however, showed that it did not differ materially in composition from the massive white clays, and that the aluminum was in combination as a silicate and not as an oxide. Veinlets of white, lustrous halloysite are associated with this concretionary layer.

Mining is carried on in an open pit, which is roughly circular and is about 250 feet in diameter. The overburden is shovelled by hand labor into dump cars which are pulled from the pit by a steam hoister, and are dumped into a near by ravine. Water is a constant source of annoyance, and it is necessary to keep a steam pump in operation to drain the pit. The clay is mined entirely by hand labor. Stakes may be driven into the top of the bed and large masses of clay pried off. This is facilitated by the intersecting jointing, and is applied only at the top of the bed. The middle and bottom of the bed is picked down with broad pointed, curved picks. Blasting with dynamite is sometimes resorted to, although the method has not found much favor. After the chunks of clay are taken from the face of the bed, they are sorted into No. 1 and No. 2 grades, determined by the color. Small, short-handled, hoe-like knives are used for cutting out the iron stains and thus obtaining the highest grade of clay.

Laboratory Tests on No. 1 Clay from the Property of the American Clay Company, Dry Branch

The following is the chemical analysis of the No. 1 paper clay:

Moisture at 100° C.	1.00
Loss on ignition, water	13.86
Silica, SiO_2	44.67
Alumina, Al_2O_3	38.76
Iron oxide, Fe_2O_3	.85
Lime, CaO	trace
Magnesia, MgO	.08
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide TiO_2	1.37
	100.59

The kaolin contains:

Feldspar	tr.	Sand	trace
Quartz	tr.		
Mica	tr.		
Ferric oxide			.85
Clay substance			99.15
Total			100.00

The above analysis is of the purest clay and does not represent the average of the clay breast.

Under the microscope, no minerals can be recognized, except milky and translucent aggregates of kaolinite, with a coating of iron oxide. Rarely muscovite and quartz particles may be detected.

The clay is very plastic, and may be worked up into a doughy mass. The average air shrinkage was 4.7 per cent. and no cracking took place during drying. The tensile strength was very low, not exceeding 12 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	6.7%	white to cream
9	14.4%	white to cream

At cone 4, the clay was white with a faint cream tinge, and developed small cracks. It was soft and friable. At cone 9, it was a white to a faint cream, steel hard, but cracked very badly. Tested in a Deville furnace it remained unfused at cone 33, 3,254° F., and in point of refractoriness, is a number one fire clay.

SLAKING.—Its slaking properties are excellent, and it might be taken for a standard for comparison purposes. A one inch cube, thoroughly air dried, slaked completely in 250 CC. of water, in three minutes. It is very fine grained, plastic or "sticky," and has good spreading qualities.

The No. 2 clay of the American Clay Co., differs from the No. 1, only in having a higher percentage of iron oxide, and a consequent darker color. It burns to a light cream color and is also highly refractory.

USES.—The output of the mine is now consumed by paper manufacturers. In addition to its being a high grade paper clay, the purest parts of the bed might be used as a china clay in the manufacture of white ware pottery, tiling, sanitary ware, etc.

I. MANDLE AND COMPANY

The property of I. Mandle and Company is located 2 miles south of Dry Branch, about 1½ miles from the Macon, Dublin and Savannah Railroad. This company mines a high-grade pottery clay. The clay is hauled by wagon from the pit to storage sheds on the railroad.

The clay pit is about 100 feet in length, and is located along a small northward flowing stream. Ten feet of clay is exposed, and the bed is reported to be 15 feet in thickness. The kaolin is white, jointed, and very free from "grit." The whole thickness is semi-hard, and not soft and cheese-like as at some other localities of the Dry Branch region. It breaks with an angular and conchoidal fracture, slakes upon weathering, and has a tendency to spall off concentrically.

The clay is for the most part white, but iron staining is observed at the top of the bed and penetrates the joints. The staining along the jointing is merely a thin coating, and does not seem to penetrate the clay mass, and in addition to the iron staining there are some occasional black stains and dendrites, probably of a manganese oxide.

The overburden is 10 to 20 feet in thickness, and consists of loose sand, containing large chunks and pellets of white clay, a greenish laminated clay layer about 4 feet in thickness, and fine, red sand. The overburden lies unconformably upon the clay bed, that is the top of the clay bed is irregular, the clay having been partly removed by erosion before the deposition of the overlying beds, so that the overburden now fills up these little erosion gullies in the clay. The result of this pre-Tertiary erosion has been to produce slight variations in the thickness of the clay beds.

There is a small circular pit about 100 yards west of the pit that is being worked. The clay and overburden in the two pits seem to be quite similar. No definite information as to the thickness of the clay in this second pit was obtained. It may be reasonably expected that the clay on the Mandle property will be of large extent areally, and will not present any considerable variations in thickness.

The property suffers somewhat from its distance from a railroad. The clay is now hauled from the mine in wagons to storage bins on the railroad, and under the present conditions one team can haul about 3,000 pounds per load, and make five or six trips per day. The distance and the topography do not preclude the laying of a spur track from the main line of the railway.

This company has no drying sheds or crushing machinery, and the clay is shipped crude and in bulk.

Laboratory Tests on the I.Mandle Kaolin

The following is a chemical analysis of the unwashed pottery kaolin:

Moisture at 100° C.	1.694
Loss on ignition, water	13.326
Silica, SiO_2	45.390
Alumina, Al_2O_3	37.204
Iron oxide, Fe_2O_3	.850
Lime, CaO	.220
Magnesia, MgO	.100
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide, TiO_2	1.546
Sulphur, S	.010
Phosphorus pentoxide, P_2O_5	.000
	100.340

The kaolin contains:

Quartz	.31
Ferric oxide	.85
Clay substance	98.84
	100.00

It will be observed that this kaolin is very low in fluxing impurities and remarkably free from sand, indeed, it is difficult to see how its purity could be appreciably increased by washing. The percentage of TiO_2 is high, as it is in all of the Fall Line clays examined, but it is not believed that it has any effect upon the color or the clay at the temperatures at which it is ordinarily burned. The ratio of silica to alumina is in excess of that of kaolinite, due probably to the presence of hydrous silica not in combination.

Under the miscroscope milky and translucent aggregates of kaolinite with coatings of yellow iron oxide, are observed; there is rarely quartz and muscovite mica. No other minerals could be recognized.

The clay is very plastic, and when made up with 35 per cent. of water, shows an average air shrinkage of 6.9 per cent. The tensile strength of the air dried briquettes is high, the sample tested, averaging 98 pounds per square inch. This exceeds the strength of the New Jersey and Florida ball clays which are similar in composition. The tensile strength of the ball clay from Edgar, Florida, is given by Ries[1] as about 65 pounds per square inch.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Absorption*
4	9%	white	14.2%
9	10.1%	white	2.7%
15	13.5%	bluish-white	1.2%

At cone 4, the clay burned pure white, but soft and porous, and showed a slight checking. At cone 9 it was steel

1. Prof. Pap. No. 11, U. S. G. S., p. 38.

hard, and showed a slight checking, and at cone 15 it was a bluish-white or gray in color, but even at this temperature was not vitrified.

The clay slakes readily in water, but does not compare favorably in this respect with the softer clays.

USES.—The clay is now being used successfully as an ingredient of white ware pottery mixtures in Northern pottery centers. Its high strength, excellent plasticity, and white burning quality, make it a very desirable clay. It will, perhaps, be found too hard for the purposes of paper manufacturers. Clays such as these, combining as they do high strength, plasticity and refractoriness, can be used alone or at least form by far the largest per cent. of clay in the body composition of white ware pottery, electrical porcelain, tiling, etc. Perhaps the chief objection to the clay is its tendency to check in burning. Should the clay be used alone, a high percentage of fluxing material would be necessary.

The following mixture was made up in the laboratory and burned at cone 9 in a muffle.

Mandle kaolin	60%
Feldspar	25%
Flint	15%
Total	100%

The mixture showed good plasticity, and gave a tensile strength, air dried, of 93 to 133 pounds per square inch. The air shrinkage was 6.4 per cent. and the fire shrinkage at cone 9 was 12.5 per cent. The sample burned white and produced an excellent body but checked badly in the burning. It is presumed that the checking was partly due to the very rapid burning to which the sample was subjected.

A second mixture was made, consisting of:

Mandle clay	50%
Feldspar	25%
Flint	15%
Whiting	10%
Total	100%

This mixture showed good plasticity, and a high air dried strength. At cone 9 it showed a fire shrinkage of 7.6 per cent., burned white, was completely vitrified, and showed no cracking or checking.

E. H. Beckley Property

A short distance southward from the Mandle pit, there is an old pit reported to be the property of Mr. E. H. Beckley. Clay was mined here several years ago, and a small drying shed was erected. The pit is filled with debris, and no detailed information concerning it was obtained. The clay and overburden, however, are probably similar to that at the Mandle pit.

Rico Kaolin Mine

The old Rico Mine is located on lot 138, 28th district, Twiggs county, and about 1½ miles east of Phillips Station on the Southern Railway. Extensive preparations were made at one time for the mining of clay on this property—machinery was installed, drying sheds erected, and a spur track built from the main line of the Southern Railway. The company in charge failed, however, before any great amount of mining was done, and the property has been abandoned since 1903.

The pit at the time of my visit, 1907, was largely filled with sand, and the full thickness of the clay bed was not exposed. The section in the pit showed 4 to 16 feet of clay overlain by 8 to 10 feet of sand. The clay bed shows variations in texture and thickness. An auger boring was made in the pit to determine the thickness and character of the clay. The first 8 feet was a soft, jointed clay, more or less stained yellow and red by iron oxide; beneath this was 8 feet of pure white, gritless clay, which was in turn underlain by a micaceous, white sand. This sand was penetrated 7 feet. This boring was made in the east end of the pit, and can be taken as representing the thickness of the bed only at this point. As will be seen from the accompanying sketch, the bed is likely to represent variations in thickness.

The overburden is soft rock, consisting of sand and clay and its removal presents no especial difficulties. The overburden will perhaps not exceed 30 feet.

In a gully 200 yards southeast of the pit, the clay bed is exposed naturally, and shows 8 feet of soft white and yellow clay, underlain by micaceous sand. An auger boring was also made 100 yards west of the clay pit, and at about the level of the clay bed in the pit. This boring showed:

Soft clay, with yellow and red iron streaks	5 feet
Soft, white clay, very free from grit	9 "
White clay, with yellow iron stains; micaceous	1 "

While the property has not been thoroughly prospected and explored, the quality of the clay and the amount already known, justify development.

There are no perennial streams or springs nearby which would supply water for boiler purposes, or for a clay washing plant, but it is believed, judging from the geology of the region, that sufficient water for these purposes can be obtained from deep wells.

Laboratory Tests

The following is a chemical analysis of the kaolin from the Rico mine. The sample was selected by the writer from the old drying beds and represents the quality of the clay which was taken out during the mining operations.

Moisture at 100° C	.781
Loss on ignition, water	12.632
Silica, SiO_2	48.580
Alumina, Al_2O_3	35.940
Iron oxide, Fe_2O_3	.850
Lime, CaO	trace
Magnesia, MgO	.108
Soda, Na_2O	trace
Potash, K_2O	.043
Titanium dioxide, TiO_2	1.600
Sulphur, S	.000
	100.534

The kaolin contains:

Quartz	6.06	Sand	6.49
Feldspar	.43		
Ferric oxide			.78
Clay substance			92.73
Total			100.00

With the exception of a higher sand content, it will be seen that this clay compares favorably in purity with the Dry Branch clays. Under the miscroscope, it consists of aggregate of kaolinite, quartz, muscovite mica, limonite, and minute particles of black minerals. The limonite forms a coating over the clay and quartz particles. The quartz is in both large and small grains, either rounded or angular, and is much the most abundant of the accessory minerals. The black minerals occur as small specks and are not easily identified; some are possibly ilmenite.

This clay is remarkably plastic, but shows a very low air dried strength, not exceeding 12 pounds per square inch. The air shrinkage of the clay, worked to its best plasticity, was 6 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	7.3%	white
5	10.1%	white
9	13.4%	white
12	no measurement, cracked badly	
14	13.4%	dull white

At cone 4, the clay was pure white, but was soft and porous, and showed checking. It became steel hard at cone 9, but remained very porous up to cone 14.

Its fusing point was determined as cone 34, and it is therefore a high grade fire clay.

Its slaking properties in water are good. It falls readily into a cream colored powder, but rapidly settles, and does not remain in suspension for any length of time.

USES.—This clay when washed should find a use in the manufacture of white ware pottery. The chief objection to it will be perhaps, its tendency to crack in burning. When burned at a high temperature, small brown specks appear, but it is believed that these are due to sandy impurities which could be eliminated by washing the clay.

The washed clay would make a good paper filler. In connection with the white sandy clays and sand occurring here, it could be manufactured into high grade fire brick and ornamental building brick.

OTHER PROPERTY NEAR THE RICO

Clay is reported at other points near the Rico mine, and doubtless occurs, but its extent and purity must remain problematical until it is thoroughly prospected.

BOND'S STORE OR DELZELL

On the Bond property and near Delzell postoffice, 12 miles south of Macon, great thicknesses of white clays are found.

On the property of B. D. Melton clay of good quality is reported to have been found in a cut of the old Macon and Birmingham Railroad. The owner of the propery reported that he bored into the clay 16 feet and found it generally soft, white and free from grit.

At the time of my visit to the cut, no good exposure of the clay bed could be seen. The clay is likely to be stained by iron oxide at the top of the bed. In mining there would be 20 to 30 feet of sandy overburden to remove. Tests made upon a sample from this location, showed the clay to be white, free from grit and very plastic. The clay showed an air shrinkage 5.5 per cent. and a very low tensile strength. The burning tests were:

Cone	*Fire-Shrinkage*	*Color*
4	8.8%	pure white
9	15.3%	white
15	15.9%	dull white

The clay checks in burning and becomes steel hard at cone 9. It is not known whether the sample tested, can be taken as representing a minable quantity or the quality of the greater part of the bed.

About ½ mile east of the Melton property, a white clay was again exposed, in a cut of the old railroad, on the property of Thomas Bond. The clay here is reported to have a workable thickness of 10 feet. The overburden is a light red, crossbedded sand, and in the cut is 15 feet in thickness.

A small amount of clay has been mined at this place. This property is three miles east of the Southern Railway track, but it is not as inaccessible as it might appear; since the road bed of the old Macon and Birmingham Railroad could be used the entire distance. But little definite information concerning the quality and thickness of the clay can be given.

In the public road, a short distance south of Bond's Store, 15 feet of semi-hard, jointed clay, is exposed, and is underlain by a soft micaceous clay, stained with iron oxide. This clay at best, can hardly be more than a fire clay. In going east from the store, there is also a fine exposure of clay, in a gully alongside the public road. The bed here seems to have been greatly eroded before the deposition of the overlying red sand. From the top of the clay exposure to the bottom, the vertical distance is 30 feet. It can not, however, be said with certainty that this represents the thickness of the bed. The clay is jointed, semi-hard, and more or less stained, and splotched with iron oxide. A sample of this clay was collected, and tested in the laboratory. The sample is from the upper part of the outcrop.

It is slightly gritty, very plastic, and has a very low tensile strength. Its air shrinkage was 4.2 per cent. The burning showed:

Cone	*Fire-Shrinkage*	*Color*
4	7.1%	gray
12	13.1%	dark gray

It cracked badly in burning, and showed small brown metallic specks.

When dry and pulverized it has a rich cream color. The clay is not likely to be of any value for white ware pottery on account of the poor color to which it burns. It is a high grade fire clay, and could be used in many fire clay and other products, but is of little value on account of its distance from transportation.

Southward from Delzell, and in the western part of the county, in the vicinity of Bullards, many exposures of white clay will be found, wherever streams have cut through the Tertiary sands, and into the underlying Cretaceous strata. It is believed that these clays belong geologically to a higher horizon than the Dry Branch clay, and it is not expected that they will attain anything like the purity and extent of the clays further north.

Reid's Station

In sinking a well on the property of Monroe Phillips at Reid's, a bluish white plastic clay was discovered. The clay was 18 feet from the surface and about 4 feet thick. This clay was tested for a ball clay.

The clay is very plastic, and possesses an air dried tensile strength of 116 pounds per square inch. It is a blue or drab when moist, and almost white when dry; very fine grained and free from any large amount of grit. It shows an air shrinkage of 7.4 per cent., and when burned at cone 4, a fire shrinkage of 9.2 per cent., and at cone 9, a shrinkage of 9.7 per cent. At cone 4 it burned to a cream color, and to a very dense body; at cone 9, the color is darker, almost a buff. The absorption at cone 9, after 48 hours' immersion was 1.8 per cent. The body was vitrified, but developed slight cracking.

While this clay does not burn pure white, it is but little inferior in respect to color, to English ball clay.

There are no natural exposures of the clay, and nothing is known of its extent. Should it prove to be in large quantity, its accessibility and nearness to kaolin deposits, will make it a valuable clay.

Myrick Mill

An outcrop of white clay about one half mile south of Myrick Mill on the property of Mrs. S. Napier, 5 miles north of Jeffersonville, was examined and a sample collected. The clay has a thickness of 12 feet. It is a light cream color when dry and very free from grit.

Its tensile strength is very low, the briquettes always breaking in the clips of the testing machine before their strength could be measured.

The clay has medium plasticity and a low air shrinkage. It burns white at cone 4, but at cone 8, is bluish white with iron specks, and cracks badly.

JONES COUNTY

This county lies partly within the Piedmont or Crystalline belt, and partly within the Coastal Plain. The southeastern part of the county, or roughly the triangle formed by the eastern and southern boundary lines and the Georgia Railroad on the north, is underlain by the Tuscaloosa (Potomac) formation, and contains valuable fire clays and kaolins. The surface deposits are mainly Eocene and Pleistocene clays and sands, and the Tuscaloosa is exposed only where stream ero-

PIT AND OVERBURDEN, GEORGIA KAOLIN COMPANY, TWIGGS COUNTY, GEORGIA.

sion has removed the overlying formations; or in artificial cuts. The most important clay locality in this county is Griswoldville.

GRISWOLDVILLE

Griswoldville is located on the main line of the Central of Georgia Railway, 11 miles east of Macon. The clay at this locality lies on the property of Mr. J. R. VanBuren, and the principal clay deposits are exposed in the railroad cuts 1¼ miles west and 2 miles east of the VanBuren residence or Griswoldville station.

The main cut west of Griswoldville, is about 200 yards long, and 40 feet deep, and one of the most interesting sections of Fall Line strata may be observed here. The clay occurs in several different beds, variable in thickness, texture, and physical properties. The walls of the cut, that on the north side of the track and that on the south side, show differences in the strata and structure, although the space between them is hardly more than 50 feet.

On the north side, at the west end of the cut, 6 feet of clay is exposed, just above the level of the railroad track. This is a soft white clay, comparatively free from grit. This shall be designated for clearness in further description, as clay bed No. 1. This bed is overlain by 15 feet of gray, kaolinic sand; some mining of the bed was done several years ago and a washing plant installed. The clay can be traced eastward in the cut, until it seems to have been entirely removed by erosion and is replaced by red sand. Gray, micaceous, clayey sands underlie the clay bed.

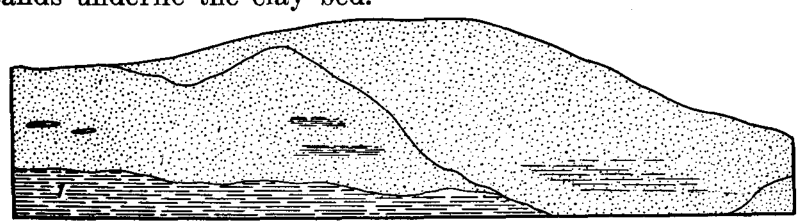


Fig. 6.—Sketch of the North Side of the Railroad Cut on the J. R. VanBuren Property. 1. White Clay Referred to in Description as Clay Bed No. 1.

Two beds of economic value occur on the south side of the track. About midway in the cut, there is a lens of hard, blue-white clay about 6 feet in thickness. This bed lies about 15 feet, vertically, above the railroad track, and seems to be merely a thin lentil of clay inclosed by sand, and is seen to thin out completely both eastward and westward within a short distance, and does not promise to be of any large extent areally, although it promises to be of some economic value. It shall be referred to as bed No. 2.

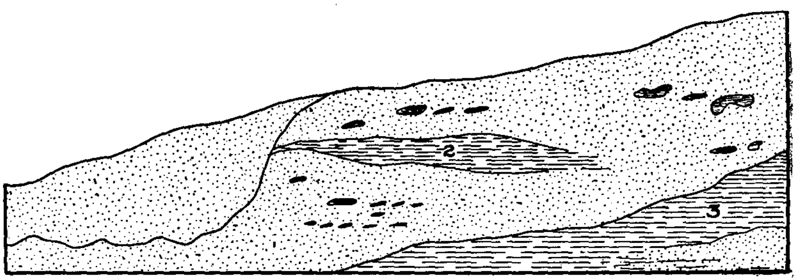


Fig. 7.—Sketch Showing the Clay Beds on the South Side of the Railroad Cut on the J. R. VanBuren Property. 2 and 3. White Clay Beds Referred to in the Description as Beds Nos. 2 and 3.

A third bed No. 3, also appears on the south side of the track. This bed reaches a thickness of about 10 feet and slopes downward rapidly until it disappears from view. This clay is white to drab and bluish-gray, is soft, and contains only a small percentage of sand, but probably somewhat more than bed No. 1, on the opposite side of the track. The sand is principally quartz and mica. The clay has the property of hardening slightly on exposure; different parts of the bed will show differences in texture and physical properties. The overburden consists of loose kaolinic sand and amounts to 20 feet. In the eastern end of the cut, it is underlain by gray micaceous sand and to some extent grades into and is replaced by sand.

The clays here are in the Tuscaloosa formation, but lie somewhat lower geologically than the Dry Branch clay. The thick Dry Branch stratum probably lies further southward but is covered by a great thickness of strata. While the clay beds here are not as extensive nor as a whole as free from sand as at some other localities there is but little question about the commercial quantity of the clay, or of its purity when washed. The property has an added advantage in being accessible to railway transportation. Water for washing purposes and power purposes can be obtained near by.

Laboratory Tests

A sample of the pure clay from bed No. 1, was a pure white, soft, friable kaolin, in which grit could be detected only by the microscope. It contains small particles of quartz, muscovite flakes, and finely disseminated iron oxide.

The following is a chemical analysis:

Moisture at 100° C.	1.201
Loss on ignition, water	13.226
Silica, SiO_2	45.530
Alumina, Al_2O_3	37.939
Iron oxide, Fe_2O_3	.850
Lime, CaO	.100
Magnesia, MgO	trace
Soda, Na_2O	trace
Potash, K_2O	.324
Titanium dioxide, TiO_2	1.481
Total	100.651

The kaolin contains:

Quartz	.00	Sand	1.58
Feldspar	1.58		
Clay substance			98.42
Total			100.00

This clay is very plastic, requires a high percentage of water for mixing, and shows a very low tensile strength. Its air shrinkage is 5.2 per cent.

Cone	*Fire-Shrinkage*	*Color*
4	4.1%	white
5	7.2%	white to faint cream
9	11.2%	white
11	11.5%	very faint cream

Its melting point is above cone 33 and is given by Ladd[1] as lying near Seger cone 36. The fire shrinkage is slightly lower than most of the other pure kaolins tested. The bricklet, burned at cone 11, cracked badly, but at lower temperatures cracking was less noticeable. The clay becomes steel hard at cone 5. A sample was burned under a clear glaze, and while it did not show a pure white, but showed a very pleasing faint cream, this defect may have been due to improper burning. This clay slakes readily in water and if washed would doubtless be a high grade paper clay.

The clay from bed No. 2, is harder than that just described and somewhat darker in color and differs in its physical properties. It has all of the properties of a ball clay, except that its vitrifying point is high. The following is a chemical analysis of a sample of crude clay from bed No. 2.

Moisture at 100° C	1.99
Loss on ignition, water	12.59
Silica, SiO_2	46.34
Alumina, Al_2O_3	35.47
Iron oxide, Fe_2O_3	1.02
Manganous oxide, MnO	trace
Lime, CaO	.00
Magnesia, MgO	.39
Soda, Na_2O	.05
Potash, K_2O	.25
Titanium dioxide, TiO_2	1.72
Sulphur, S	.00
Total	99.82

Amounts insoluble in sulphuric acid:

Alumina	.23
Ferric oxide	.08
Sodium oxide / Potassium oxide	.17
Titanium dioxide	.02

The kaolin contains:

Feldspar	1.31	Sand	3.46
Quartz	2.15		
Clay substance			96.54
Total			100.00

1. Geological Survey Georgia, Bulletin No. 6-A, p. 108.

The clay is fine grained and plastic. The percentage of water required for mixing was 43 per cent. It showed an air shrinkage of 8.7 per cent. which is higher than that of the soft white kaolins.

Burning Tests

Cone	Fire-Shrinkage	Color	Condition
4	6.4%	dull white	steel hard
7	10.3%	dull white	slight cracking
12	10.6%	cream color	not vitrified

In the Deville furnace it was unfused, but vitreous at cone 30. The fire shrinkage seems to be less than in the soft, white kaolins, and checking and cracking in burning is not as noticeable. It burns to a denser body than the soft kaolins of low strength, but is by no means impervious even at cone 12. The water absorption was high and of no value on account of the water included in the small cracks or checks developed in burning.

In making the strength tests, 10 briquettes were broken. There was considerable variation in the strength; the average was 103 pounds per square inch.

Tests on Clay from Bed No. 3, Griswoldville

This clay is similar to that from bed No. 2, just described, probably containing a larger percentage of sand. It showed an air shrinkage of 8.2 per cent; water required for mixing 40 per cent.

The tensile strength was high, 131 pounds per square inch.

Burning Tests

Cone	Fire-Shrinkage	Color
4	8.1%	white
8	10.0%	white
15	10.4%	cream

A mixture was made consisting of:

Clay from Bed No. 1, washed	40%
"Ball" clay, bed No. 2, crude	20%
Feldspar	25%
Flint	15%
Total	100%

The mixture showed good plasticity, an air dried strength of 50 to 60 pounds per square inch, and at cone 9 burned white to a dense body without checking.

USES.—These clays combining as they do, plasticity, strength and white burning qualities, offer possibilities for white ware pottery, porcelain tiling, etc. They have a fusing point above cone 33, and in connection with the white clayey sands and the overlying impure clay and sand of the Tertiary could be used in the manufacture of fire brick and ornamental building brick.

The white clay when washed will be suitable for use in the paper industry. It is fine grained, plastic or "sticky," and slakes readily in water.

In the railroad cuts, 2 miles east of Griswoldville and on the VanBuren property, white clay and kaolinic sands are found and are similar, in occurrence, to the clays in the west cut, just described. That is, they are lenticular layers, variable in their thickness and amount of sand and may grade into or be replaced by sand. Two beds were noted here, each with a thickness of 6 feet exposed.

It is probable that a greater thickness will be found. A small amount of fire clay has been mined from this place and shipped to Chattanooga, Tenn., for fire brick purposes. The overburden is not excessive and the clay can be easily mined. This clay is probably best adapted for fire clay products.

White clay is exposed at other localities on the VanBuren property. South of the residence, one fourth mile, 8 feet of white clay is known to occur. This clay is sandy and at the surface is streaked red and yellow by iron oxide. In a cut of the railroad, 3 miles west, a clay bed of the Tuscaloosa, lying at the base of the cut, is exposed for a distance of 500 yards. It is 4 to 10 feet in thickness and changes from soft, white clay to a hard clay which is probably 50 per cent. sand. This may be excellent material for certain refractory purposes.

WILKINSON COUNTY

Throughout the northern part of Wilkinson county, there are numerous natural exposures of the white clay of the Tuscaloosa formation. This county lies wholly within the Coastal Plain area; the surface was originally entirely covered by the sands and clays of the Teritary, and the white clays of the Tuscaloosa will be found in gullies, or stream valleys where the overlying formations have been removed by erosion.

The principal points where clays have been noted, are Lewiston, Gordon, McIntyre, and Toomsboro.

The deposits are entirely undeveloped, with the exception of the Lewiston deposit, and are probably in the main suited only for fire clay products, although some of them give promise of being pottery and paper clays.

Lewiston

Lewiston Kaolin.—A deposit of white clay occurs one mile west of Lewiston, on the Central of Georgia Railway. The property is owned by Mr. J. W. Huckobee, who opened up a clay mine here in 1893. A high grade clay was placed on the market and was sold chiefly as a filler for wall paper, though some of it is reported to have been used in the manufacture of white ware pottery. Work was abandoned here in 1902, and since that time only small amounts of clay have been mined for fire clay products. Three pits were worked on the east side of a north-south ravine; but at the time of my visit these were largely filled up by debris from the overburden, and the full thickness of the clay beds could not be seen. In the north pit, nearest the railroad, Mr. Huckobee, the owner of the property, reports that he found a thickness of 12 feet of clay. This bed, however, is seen to thin out rapidly to the north.

The property was examined by Dr. G. E. Ladd[1] during mining operations and the clay beds were reported by him to vary in thickness from 3 to 8 feet, and to be massive in structure. The overburden for the most part is red clay-sand, and is unconsolidated, and amounts to from 10 to 20 feet. From a study of the exposures here, it is quite likely that the clay beds will be found to show considerable variations in thickness, and also in quality and texture.

The purity of some of the clay found here, however, would seem to justify thorough prospecting to determine the extent and quality of the beds.

A small sample of the clay selected from the old drying shed, was white, with a faint cream tint, very soft and friable, and free from grit. It was very plastic and slaked readily in water, and it showed an air shrinkage of 6 per cent. The air shrinkage will depend upon the amount of water used in mixing, and the above shrinkage is from a sample made up to its maximum plasticity.

The tensile strength is low, the sample tested not exceeding 12 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	9.5% (a)	white
8	11.9%	light cream
12	12.3% (b)	cream

(a) Total air and fire-shrinkage.
(b) Cracked badly, measurement not entirely correct.

The clay burned steel hard at cone 8 with only slight checking; at cone 12, it was cracked badly. It is highly refractory; according to Ladd[2] its fusing point approaches

1. Georgia Geological Survey, Bulletin No. 6-A, p. 112.
2. Georgia Geological Survey, Bulletin No. 6-A, p. 115.

Clay Pit of the Georgia Kaolin Company, Twiggs County, Georgia.

that of Seger cone 36. The following is a chemical analysis[1] of the purer clay from this locality:

Moisture	0.99
Loss on ignition, water	12.98
Silica, SiO_2 (combined)	44.92
Silica, (sand)	1.55
Alumina, Al_2O_3	39.13
Iron oxide, Fe_2O_3	1.05
Lime, CaO	0.40
Magnesia, MgO	0.17
Potash, K_2O	trace
Soda, Na_2O	trace
Total	99.20
Clay base	97.03
Fluxing impurities	1.62

GORDON

There are numerous exposures of white clay in the vicinity of Gordon. Near the base of the ridge, lying 1½ to 2 miles south of the town, beds of white clay 12 to 15 feet thick are seen at a number of places in roadways and gullies. It is probable that there is a continuous bed of white clay several miles in extent, lying at the base of the Tertiary ridge on the south side of Commissioners Creek. The following is a geological section made along the public road 1½ miles south of Gordon:

1	Red sand, with small quartz pebbles	40 feet
2	Red, orange and brown sand, with thin clay laminae	15 "
3	Greenish to drab, massive clay	50 "
4	Bluish, clayey sand	10 "
5	White, plastic clay	12 "

The Tuscaloosa white clays are generally somewhat harder than the clays of the Dry Branch region, and are minutely jointed and stained red or yellow along the joint planes; until finely ground, they have a tendency to be *mealy* rather than *unctuous* as in the case of the soft paper and pottery kaolins. The amount of sandy impurities is variable, from gritless clay to hard beds which may be 50 per

1. Bull No. 6-A, p. 115, Geol. Surv. of Ga.

cent. quartz sand. These clays are in all cases highly refractory, having fusing points from cones 30 to 35. They are suitable for fire clay products but those examined do not give much promise of being of value for pottery or paper purposes. These clays are entirely undeveloped.

On the Z. T. Miller place, 3 miles south of Gordon, there is a bed of white clay remarkable for its thickness, physical properties, and as a whole for its purity. There is a natural exposure here of 30 feet of white clay. It seems to lie in the same geological position as the clays further north and is overlain by plastic, tough, impure clays and red sand. It is hard, but is not solid or brittle, but breaks with an earthy fracture and the bed, being massive and showing no laminations, would be difficult to mine. It has the property of hardening slightly upon exposure to the atmosphere, and has been sawed and cut out into blocks and used locally to a small extent in the construction of chimneys and foundations. The bed has a curious pitted surface, due to the weathering out from the clay mass of small nodules. These *nodules* consist of small fingers and worm shaped forms, which may be one-fourth inch in diameter and two or three inches in length, perfectly round marbles or pisolites from the size of a pea to that of a walnut, and many peculiar nondescript forms. Some of these nodules have been found to be bauxite. The clay is probably best adapted for fire clay products; its hardness and lack of plasticity destroy its value for pottery and paper purposes. Having little or no plasticity and a low tensile strength, it would have to be mixed with a stronger clay. The value of the clay suffers from its distance from a railway.

A chemical analysis of this clay by Dr. Ladd gave the following results:

Hygroscopic moisture	0.21
Combined Water, carbon dioxide, etc.	14.52
Combined silica	42.79

Free silica, or sand	.82
Alumina	40.42
Ferric oxide	.70
Potash	trace
Lime	.37
Soda	.83
Total	100.45
Clay base	97.73
Fluxing impurities	1.90

This clay absorbs 80 per cent. of its weight of water. Its specific gravity ranges from 1.89 to 1.94. Bricklets shrink, on drying, 8 per cent. of their length, and an additional 4 per cent., on burning. They have a tensile strength, dried, of less than 10 pounds per square inch. It burns snowy white, with a strong tendency to crackle. Its fusing point is very high, nearly equal to that of Seger cone 36.

Southward from the Miller place there are numerous other exposures of white clays, all being highly refractory and possibly some are of great purity.

Throughout the valley of Big Sandy Creek there will be found numerous outcrops of white clay, none of which are at present of any value on account of their distance from railway lines and on account of the great abundance of pure clays at other more accessible localities.

McIntyre

White clays of the Tuscaloosa are especially abundant in the vicinity of McIntyre, and the beds, here, present a variety of phases, hard pisolitic or concretionary clay to semi-hard, and soft, white or cream colored, gritless kaolins.

Dr. N. T. Carswell Property.—Natural exposures of white clay may be seen on this property, located 3 miles east of McIntyre and accessible to the Central of Georgia Railway. The exposures vary from 4 to 12 feet in thickness and consist of both hard and soft clays. Some considerable prospecting has been done to determine the extent and quality of the clay, and judging from natural exposures, and records of shafts and auger borings, there can be no question about the great quantity of clay.

The white clay beds are overlain by 30 to 50 feet of red sand and impure clays. The overburden may contain local indurations, but is not consolidated to such an extent that its removal would give any special difficulty. The soft clay which was exposed at the time of my visit to the property, was considerably stained a pink or yellow by iron oxide. The staining seemed to persist through the mass of the bed and was not merely a surface stain. Should this staining be found to persist throughout the extent of the bed, it will of course greatly detract from the value of the clay for pottery and paper purposes. A sample of this clay examined in the laboratory was almost entirely free from quartz particles or grit. The color of the clay, which is a cream color or pink, is due to thin films or coatings of limonite and hematite over the clay particles.

It is very plastic, and when worked up with 32 per cent. of water, showed an average air shrinkage of 5.6 per cent. The air dried tensile strength did not exceed 15 pounds per square inch. At cone 5, 2,246° F, it showed a fire shrinkage of 9.3 per cent., burned to a light cream color and cracked badly; at cone 9, 2,390° F., it showed a fire shrinkage of 14.8 per cent. and burned to a buff color; at cone 15, it burned to a dark buff or leather color, showed excessive shrinkage and cracked badly. Its fusing point lies above cone 30, 3,146°F. The clay slakes readily in water, but it was observed that the stained portions of the cube tested did not disintegrate as readily as the white parts. The following is a chemical analysis of this clay:

Moisture at 100° C	.904
Loss on ignition, water	13.474
Silica, SiO_2	44.220
Alumina, Al_2O_3	38.407

Iron oxide, Fe_2O_3	1.707
Manganous oxide, MnO	trace
Lime, CaO	trace
Magnesia, MgO	trace
Soda, Na_2O	trace
Potash, K_2O	.281
Titanium dioxide, TiO_2	1.486
Sulphur, S	trace
Total	100.479

The clay contains:

Feldspar	.371	Sand	.826
Quartz	.455		
Clay substance			99.174
Total			100.000

The tests made do not indicate that this clay is likely to be suitable for white ware pottery, on account of the dark color to which it burns. However, upon further exploration of the deposit it is quite possible that purer clays will be found. This clay offers opportunities for the manufacture of fire clay products and ornamental building brick. The cracking, so pronounced when the clay is burned alone, is obviated by the addition of a small percentage of sand, and clayey sands suitable for this purpose can be found nearby.

On this same property, there is a bed of hard, pitted clay, somewhat similar to that just described on the Miller place page 162. Blocks of this clay have been sawed out at various times for building chimneys; it is a dull white in color, but contains small iron oxide stains throughout. It is very free from grit, but lacks plasticity and has a low tensile strength, the sample tested showed 28 pounds per square inch.

It is very refractory having a fusing point at cone 34. It could be used in fire clay mixtures. The following is a chemical analysis of this clay:

Moisture at 100° C	0.89
Loss on ignition, water	14.10
Silica, SiO_2	43.57
Alumina, Al_2O_3	39.34

Iron oxide, Fe_2O_3	.72
Lime, CaO	.00
Magnesia, MnO	.10
Soda, Na_2O	.05
Potash, K_2O	.10
Titanium dioxide, TiO_2	1.61
Sulphur, S	trace
Total	100.48

Rational analysis:

Feldspar	.84	Sand	.84
Quartz	trace		
Clay substance			99.16
Total			100.00

This clay as seen by the above analysis is as pure chemically as the soft kaolins. Yet, its physical properties unfit it for the uses to which kaolins are put. There is nothing in the analysis which will afford any explanation of its peculiar hardness. The writer suggests that this hardness may be due to the presence of a colloidal silica, which upon exposure to the atmosphere hardens and forms a bond for the clay particles. This clay has been mistaken for bauxite.

RED CLAY.—In prospecting his property, Dr. Carswell discovered a red clay which is noteworthy on account of its very peculiar composition. The clay is a red or pink in color, soft, but brittle when dry and free from sand. In composition it is a natural mixture of almost pure clay or kaolin and of red iron oxide. A chemical analysis of a sample, sent to the State Geological Department by Dr. Carswell, is given below:

Moisture at 100° C.	0.58
Loss on ignition	12.42
Silica, SiO_2	39.88
Alumina, Al_2O_3	34.36
Iron oxide, Fe_2O_3	11.73
Lime, CaO	0.00
Magnesia, MgO	0.00
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide, TiO_2	1.49
Total	100.46

A small sample tested in the laboratory showed good plasticity; air dried tensile strength 20 to 25 pounds per square inch; at cone 4, it burned to a chocolate color, showed high shrinkage and cracked badly; at cone 13, it was almost black in color. It was completely melted at cone 30.

This peculiar clay is reported as having a considerable thickness and some economic use for it may be found in the future.

HATFIELD PROPERTY.—This property is located on the south side of the Central of Georgia Railway track, 1½ miles west of McIntyre, and is favorably located in regard to transportation facilities.

The bed outcrops at the base of the Tertiary ridge, which lies on the south side of Commissioners Creek, and is prominent from Gordon eastward to Toomsboro. The clay is white, semi-hard and very free from grit; but contains some iron staining along the joint planes, and also small clay nodules which may be replaced by iron oxide. A thickness of 30 feet has been found at one place by sinking a shaft and boring with an auger. Outcrops of the clay bed are observed in gullies to the east of the shaft. Should the bed be thoroughly prospected or opened up by a pit it is not improbable that the clay will be found softer than at the surface. The overburden consists of the red sands and impure clays of the Tertiary, and will be found to be unconsolidated.

The following is a chemical analysis of this clay:

Moisture at 100° C.	.403
Loss on ignition, water	13.565
Silica, SiO_2	45.570
Alumina, Al_2O_3	38.340
Iron oxide, Fe_2O_3	1.020
Lime, CaO	.000
Magnesia, MgO	trace
Soda, Na_2O	trace
Potash, K_2O	.075
Titanium dioxide, TiO_2	1.380
Total	100.353

The kaolin contains:

Feldspar	.12	Sand	.32
Quartz	.20		
Clay substance			99.68
Total			100.00

The clay is very plastic, free from grit and when dry, white in color. Its air shrinkage is 5.2 per cent., its tensile strength is quite low, not exceeding 15 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
1	4.0%	white
4	4.3%	white
9	12.8%	light cream
12	13.0%	cream

It checks in burning and is soft and friable at cone 9. It burns to a dense body at cone 12, but when burned alone cracks badly. While the sample tested does not burn to quite as pure white as is desirable, this clay, notwithstanding, gives some promise of being suitable for white ware bodies, and further exploration of the deposit might reveal purer clay.

The clay is not fused until cone 34 is reached and is therefore highly refractory and a No. 1 fire clay.

Crude and in lumps it would probably be too hard for a paper filler, but if finely ground or washed there is no reason why it should not be suitable, as it has excellent plasticity or spreading qualities and is comparatively free from quartz and mica.

ROBERT BILLION PROPERTY.—This location is 3 miles northwest of McIntyre. The clay is exposed in a deep gully oppo-

CLAY PIT OF THE AMERICAN CLAY COMPANY, TWIGGS COUNTY, GEORGIA.

site the residence of Mr. William Snow. The following is the geological section exposed:

1	Fine red sand	15 feet
2	Yellow sand	5 "
3	Stiff, tenaceous clay, resembling the Eocene clay to the southward	6 "
4	Very fine red and yellow sand	15 "
5	Soft, white and cream-colored kaolin	12 "

Some parts of the clay bed are absolutely free from gritty particles, but it becomes somewhat micaceous near the top.

The following is a chemical analysis of a sample of this clay as it occurs in a state of nature:

Moisture at 100°C	.16
Loss on ignition, water	13.72
Silica, SiO_2	44.92
Alumina, Al_2O_3	40.04
Iron oxide, Fe_2O_3	.68
Lime, CaO	.00
Magnesia, MgO	.00
Soda, Na_2O	.08
Potash, K_2O	.12
Titanium dioxide, TiO_2	1.38
	101.10

Rational analysis:

Feldspar	.28	Sand	.48
Quartz	.20		
Clay substance			99.52
Total			100.00

Under the microscope the only minerals recognizable were aggregates of kaolinite, or clay substance, minute quartz particles and scales of muscovite mica. The clay is a faint cream color when dry and pulverized; it has good plasticity but a low tensile strength. The average air shrinkage of the sample tested was 5.8 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	7.6%	chalky white
9	11.5%	white
11	11.6%	faint tinge of cream
15	14.3%	faint cream

It burned steel hard at cone 9 and showed slight cracking when burned alone. With its chemical purity and its white burning properties, it gives some promise of being a suitable clay for white ware mixtures. Its good plasticity and freedom from grit should make it a good paper clay.

In the Deville furnace, it was unfused at cone 30, but was completely fused at cone 36.

The property is entirely undeveloped and no prospecting has been done to determine the extent of the bed and no tests have been made on a commercial scale. Its distance from a railway line is at present a considerable disadvantage.

GEO. BENTLEY PROPERTY.—This locality is 2½ miles north of the 159 mile-post on the Central of Georgia Railway. The clay is exposed in a gully alongside a public road and is 12 to 15 feet in thickness. It is hard and parts of the bed somewhat resemble the hard clay, No. 2, at Griswoldville. Near the bottom of the gully there is a hard clay which when dry will break into very small nut-like or conchoidal fragments when struck with a hammer. The clay mass is a cream color but contains veins of pure white clay, halloysitic in appearance.

This clay is too hard to be of value as a paper filler, and burns to too dark a color to be of value as a kaolin. It has, however, a high air dried strength, burns denser than the pure white clays, and may to some extent answer the purpose of a ball clay. The following is a chemical analysis of crude clay from this locality:

Moisture at 100° C.	3.37
Loss on ignition, water	12.31
Silica, SiO_2	49.07
Alumina, Al_2O_3	31.60
Ferric oxide, Fe_2O_3	1.70
Manganous oxide, MnO	.03
Lime, CaO	trace
Magnesia, MgO	.82

Soda, Na_2O	trace
Potash, K_2O	.36
Titanium dioxide, TiO_2	1.29
Total	100.55
Fluxing impurities	2.91

The clay contains:

Sand	9.16
Clay substance	90.84
Total	100.00

Physical Tests on the Bentley Clay

Air shrinkage 9.6 per cent.; plasticity good, when the clay is finely ground; the air dried tensile strength showed considerable variation, one briquette reaching 160 pounds per square inch; and the average was 100 pounds per square inch.

Cone	*Fire-Shrinkage*	*Color*	*Condition*
4	9.7%	gray	steel hard
9	10.0%	gray to buff	very dense

TOOMSBORO

There are a number of outcrops of the white clays of the Tuscaloosa formation near this place. A sample was taken from the bed occurring near the town. It showed fair plasticity and an air shrinkage of 3.5 per cent. At cone 4, 2,210° F., it showed a fire shrinkage of 5.1 per cent., and burned to a dull white with brown metallic specks without checking. At cone 9, 2,390° F., the fire shrinkage was 6.6 per cent.; the brick-let showed a slight cream color and black metallic specks. The explanation of the low shrinkage, is that the clay contained a high percentage of quartz and mica sand. Were the clay washed, the black specks developed in burning would probably not appear, as they seem to be fused grains of some iron mineral. This clay is highly refractory and could be used for fire clay products. No good exposures of the bed could be obtained, and it is possible that purer clays can be found. Some effort was made several years ago to mine this clay.

OTHER LOCALITIES IN WILKINSON COUNTY.—An outcrop of white clay was observed in a cut of the Central of Georgia Railway at Beechhill, four miles east of Toomsboro. A number of outcrops of both hard and soft white clays were also noted in the region lying directly north of Toomsboro. Thick beds of high-grade fire clay will be found south and southeast of Irwinton, but these, because of their inaccessibility, are valueless at present. There are numerous natural exposures in the vicinity of McIntyre, which it was not possible to visit and describe.

BALDWIN COUNTY

The most notable clay deposits in this county are at Stevens Pottery, located on a branch of the Central of Georgia Railway, 9 miles south of Milledgeville. At this point is located the manufacturing plant of Stevens Brothers and Company. This company manufactures fire brick, and locomotive tiling, sewerpipe, drain tile, fire proofing, flue linings, etc., and is one of the largest companies manufacturing clay products in the State.

Fine exposures of the clay beds and overburden may be seen in the pits to the south of the plant. In the first pit south from the plant, and on the east side of the railroad track, the following geological section could be seen at the time of my visit:

1	Red to orange, clayey sand	12 feet
2	Yellow ocherous sand	18 "
3	Soft, white to yellow fire clay	10 "

Nos. 1 and 2 constitute the overburden. No. 2 is a yellow sand, highly ferruginous, containing thin layers of limonite one or two inches thick, and kidney-shaped or potato-shaped, hollow limonitic nodules. Both Nos. 1 and 2 are rather coarse sand; small pebbles of quartz occur, but are not abundant. The overburden is unconsolidated. The fire clay bed is a soft, white to yellow, jointed clay, showing red and yellow streaks of iron oxide. The bed is massive in structure, showing no laminations or stratification lines, and varies in thickness from 8 to 20 feet. The variation in thickness is due both to irregularity of deposition and to erosion of the bed before the deposition of the overburden. The occurrence of the clay here is typical of the Fall Line clays. The clay itself does not differ in structure and composition from the soft clays of the Dry Branch region, except that it contains on the whole a higher percentage of iron oxide.

This pit is being worked and the clay used in the manufacture of fire clay products and sewer pipe. The overburden is removed by a steam shovel. Only the east side of the pit is being worked, but white clay is also exposed on the west side of the pit; but the beds seem to be thinner and more variable than on the east side.

The section in an abandoned pit on the west side of the railroad track is:

1	Coarse, red to pink, crossbedded sand, containing clay pebbles and clay conglomerate	6 feet
2	Tough, white clay, containing about 50% sand	5 "
3	Drab kaolin, more or less sandy	5 "
4	Thin limonitic layers and concretions and ferruginous sand.	3 "
5	White and yellow, fine, micaceous sand	6 "
6	White clay	1 foot

It seems quite probable that Nos. 2, 3, 4 and 5 of this section correspond to No. 2 of the preceding section. No. 1 contains hard, water-worn clay pebbles and a curious, soft clay conglomerate. The clay pebbles approach kaolin in chemical composition, and were evidently torn from sedimentary kaolin beds. They are quite hard and flint-like, and it requires a strong blow with a hammer to break them. The clay conglomerate is composed of small rounded pellets of soft white clay imbedded in a matrix of bluish and darker colored clay. Neither the pebbles nor the conglomerate are of any commercial value, but are of much scientific interest on account of the light they throw on the conditions of deposition of the strata.

The Tuscaloosa strata are overlain unconformably by Tertiary strata. About one-fourth of a mile south from the plant, there is 30 to 40 feet of stiff tenacious blue to red clay appearing much like the Tertiary clay in the vicinity of Gordon and McIntyre. This clay is used to a small extent as a bond for the fire clay in the manufacture of fire brick.

In the lower pit on the east side of the railroad, the following section may be seen:

Sand	8 feet
Sand and micaceous clay	4 "
Kaolin	3 "

This pit is now abandoned.

In a pit 1½ miles southwest of the station, there are 8 feet or more of hard, bluish-white, rather minutely jointed clay. The amount of overburden is small, 4 to 10 feet, but will gradually increase. The thickness of the clay is not constant, and it is seen to grade into a hard, sandy, impure clay. The clay bed is underlain by thin layers of red and yellow siliceous iron oxide. This clay is highly refractory and should be suitable for fire clay products.

While the clay beds on the property of this company will present variations in thickness and texture, as is the case throughout the whole Fall Line region, the quantity of high-grade fire clay may be considered, for the needs of the present plant, practically inexhaustible.

The chemical analysis of a fire clay from this property, by Ladd,[1] is given below. While this analysis is not of the fire clay which is now being used, it is nevertheless representative of the character of the clay occurring here. All of the

1. Bulletin 6-A Georgia Geological Survey, p. 139.

beds here are similar in composition, showing only slight variations in the amount of iron oxide and sand.

Analysis of Fire Clay From Stevens Pottery

Moisture	0.72
Loss on ignition	13.64
Silica (combined), SiO_2	43.85
Sand	2.77
Alumina, Al_2O_3	38.28
Ferric oxide, Fe_2O_3	1.02
Lime, CaO	0.18
Magnesia, MgO	0.00
Potash, Na_2O	0.05
Soda, K_2O	0.08
Total	99.87
Clay base	95.77
Fluxing impurities	1.33

The tensile strength of this clay is given as 24 pounds per square inch, and its fusing point as about Seger cone 35, 3,326° F.

For the manufacture of fire brick a mixture of the high-grade fire clays and the impure Tertiary clay, above mentioned, is used. The high-grade fire clays, here, have fusing points from cones 32 to 35, but the small percentage of impure clay used, reduces the fusing point of the fire brick to about cone 30. The fire brick are usually burned to cone 6.

The sewer pipe is made from a mixture of fire clay and plastic alluvial clay from Milledgeville, about 20 per cent. fire clay and 80 per cent. alluvium. For the larger sized pipes the amount of refractory clay is increased. The fire proofing is made entirely from the refractory clays.

Other Localities.—Northward from Stevens Pottery the Cretaceous rocks have been largely removed by erosion, and the decomposed crystalline rocks underlying are visible. No other white clay deposits likely to be of commercial value are known to the writer. North of Milledgeville only the crystalline rocks are exposed, though deposits of white clay are likely to be found both east and west of Stevens Pottery near the Wilkinson county line.

WASHINGTON COUNTY

In the northern and western parts of this county there are extensive beds of white clays. Most of these clays are only fire clays; all very highly refractory, however; but some give promise of being more valuable than fire clay. Much of the white clay of this county is so inaccessible, as to be almost valueless at present for any purpose. The surface is largely covered by Tertiary sands and clays, and the Cretaceous is exposed only along stream valleys where erosion has been most active.

SANDERSVILLE.—On the property of Chas. Rollins, 6 miles west of Sandersville, on the Deepstep road, there is a natural exposure of 16 feet of white clay. This bed outcrops near the base of a steep hill, sloping into the valley of Keg Creek. The bed is overlain by 50 feet of greenish, shale-clay and red sand. The deposit is typical of much of the clay lying north and west of Sandersville. The clay is minutely jointed, so that it crumbles when picked into, is a drab or cream color becoming white when dry, and frequently contains coarse quartz particles. A sample for laboratory tests was taken from the exposure near the bottom. The following is a chemical analysis:

Moisture at 100° C.	0.96
Loss on ignition	11.82
Silica, SiO_2	50.12
Alumina, Al_2O_3	33.09
Ferric oxide, Fe_2O_3	1.19
Lime, CaO	trace
Magnesia, MgO	0.08
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide, TiO_2	2.26
Total	99.52

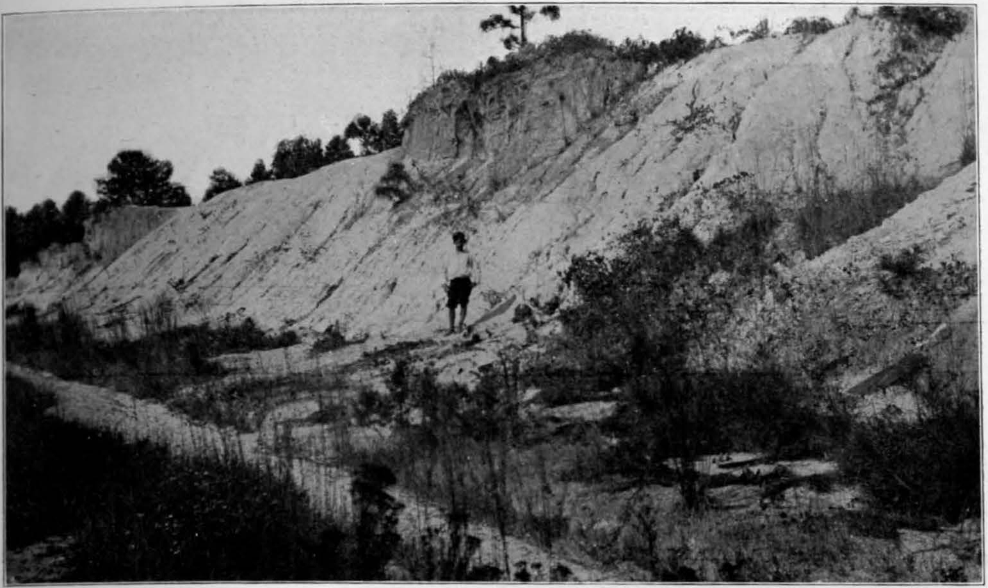


FIG. 1.—CLAY BED, RAILROAD CUT, PROPERTY OF J. R. VAN BUREN, GRISWOLDVILLE.

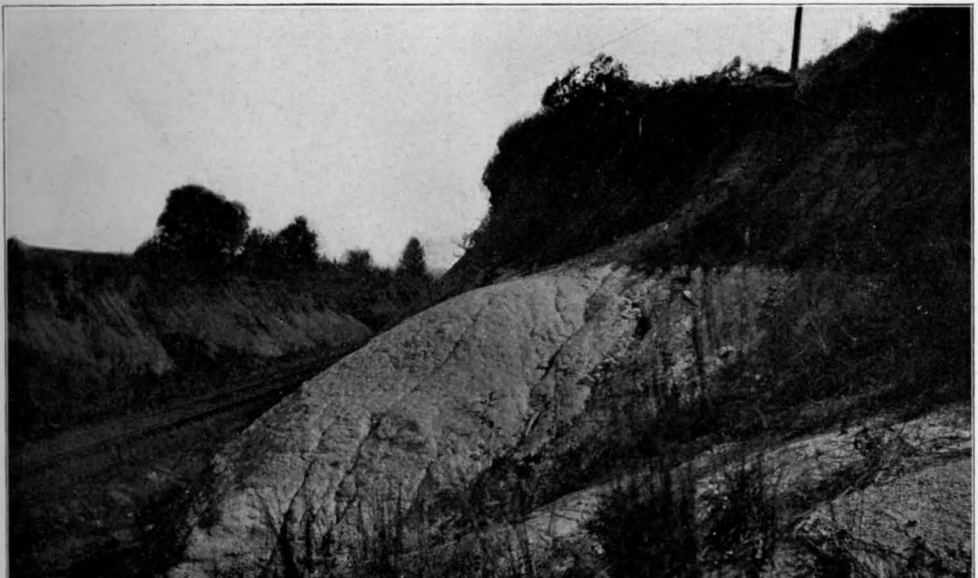


FIG. 2.—CLAY BED, PROPERTY OF J. R. VAN BUREN, GRISWOLDVILLE.

The clay contains:

Quartz sand	12.68
Clay substance	87.32
Total	100.00

Physical Tests

Water required for mixing	30%
Plasticity	medium when clay is finely ground
Air-shrinkage	2.9%
Slaking property	fair
Tensile strength (average)	27 lbs. per sq. inch
Cone 5—	
Fire-shrinkage	9.0%
Color	cream
Condition	steel hard
Cone 8—	
Fire-shrinkage	13.0%
Color	light buff
Condition	slight checking
Cone 14—	
Fire-shrinkage	———
Color	light buff
Condition	slight checking
Fusing point	above cone 31

The clay shows poorer plasticity and slaking qualities, and burns to a darker color than the soft, pottery and paper kaolins of other localities; and its most valuable quality is probably its refractoriness.

The air shrinkage is low, which is due perhaps to the high percentage of quartz sand, as shown by the above chemical analysis.

Northwest of Sandersville, about 5½ miles, near the site of the old Carter Mill, there is a natural exposure of 6 feet of "chalk" or white clay. From its physical appearance, it will doubtless have similar properties to the Rollins clay just described. One mile further north along the public road there is an outcrop showing a thickness of 12 feet of semi-indurated, jointed, white clay. There is doubtless a very extensive bed of this clay through this region, and there is some probability that the outcrops just mentioned, and that on the Rollins property are exposures of the same bed, which is continuous throughout this part of the county.

CHALKER.—Chalker is located on the Augusta Southern Railway, 14 miles northeast of Sandersville. About one mile south of the station in a railroad cut there is an exposure of the white, Tuscaloosa clay. The bed shows a maximum thickness of 12 feet or more, and is overlain by 40 to 50 feet of Tertiary sand and clay and sandstone. The sandstone is gray, micaceous and is thinly laminated and is something in the nature of a whetstone or grindstone. It may be 2 or 3 feet in thickness, and may lie directly above and in contact with the white clay. The white clay is sandy and somewhat hard at the top of the bed, becoming softer towards the bottom. It is rather a dull drab in color. Its chief qualities are comparatively high tensile strength and dense burning properties. The following is a chemical analysis of the semi-hard clay:

Moisture at 100° C.	0.20
Loss on ignition, water	10.92
Silica, SiO_2	52.30
Alumina, Al_2O_3	32.88
Iron oxide, Fe_2O_3	1.36
Manganous oxide, MnO	trace
Lime, CaO	0.00
Magnesia, MgO	0.18
Soda, Na_2O	0.24
Potash, K_2O	0.71
Titanium dioxide, TiO_2	1.56
Total	100.35

Rational analysis—

Feldspar	0.82	Sand	14.67
Quartz	13.85		
Clay substance			85.33
Total			100.00
Fluxing impurities			2.49

The results of the physical tests were: Color, drab to white; plasticity, good; air shrinkage, 5.7 per cent. The tensile strength was 127 pounds per square inch.

The burning tests showed:

Cone	Fire-Shrinkage	Color	Condition
1	.....	white	soft
5	5.6%	cream	almost steel hard
8	7.5%	cream	steel hard
13	7.5%	cream	steel hard, not vitrified

It burns without cracking, due doubtless to the high percentage of sand that it contains.

Its slaking properties are fair, but it tends to be rather granular; a one-inch cube slaked to a fine granular mass in 10 minutes. See slaking tests on another page.

This clay might be of value as a bond for the soft, white clays of other localities, which show low tensile strength. Alone, its color both in the raw and burned conditions, is too dark to make it of value for pottery or paper purposes.

Warthen.—Near the old Warthen mill, 2½ miles west of Warthen, a station on the Augusta Southern Railroad, there is an outcrop of white clay, which seemed to be of excellent quality. The clay was soft and white, but only 2 or 3 feet was exposed, and no definite information was obtained as to its thickness or extent.

Other Localities in Washington County.—In the western part of the county, exposures of Cretaceous strata are numerous, and white clays undoubtedly occur in great abundance, but on account of their great distance from railway lines, they are at present of little or no value.

On the property of Mrs. S. M. Gilmore, 10 miles north of Oconee, there is a fine natural exposure of white clay, about 1½ miles southeast of the Gilmore residence. There is a thickness of 15 feet exposed, overlain by 20 to 30 feet of red mottled sand. This clay is both hard and soft, and shows considerable variation in its sand content. It burns white, and is highly refractory, and in addition to being a high-grade fire clay, gives some promise of being suitable for white ware.

The following is a chemical analysis of a sample of the purest clay from this property:

Moisture at 100° C.	0.56
Loss on ignition, water	13.53
Silica, SiO_2	44.43
Alumina, Al_2O_3	38.66
Iron oxide, Fe_2O_3	.85
Lime, CaO	.00
Magnesia, MgO	.03
Soda, Na_2O	trace
Potash, K_2O	.31
Titanium dioxide, TiO_2	1.93
Total	100.30

Rational analysis:

Feldspar	1.25	Sand	1.46
Quartz	0.21		
Clay substance			98.54
Total			100.00

GLASCOCK COUNTY

Gibson.—Gibson is located on the Augusta Southern Railroad, 50 miles southwest of Augusta. Large undeveloped deposits of both kaolin and fire clay occur near this place. A very extensive bed of Tuscaloosa white clay occurs on the property of J. Newsome, 3 miles east of Gibson. The clay outcrops on the east side of Deep Creek at the base of a low sloping hill. The following geological section illustrates the position of the kaolin bed, and the nature of the overlying strata making up the hill:

Red, crossbedded sand, capping the hill	30 feet
Drab and greenish, soft, impure clays	20 "
Thin bedded, soft, fossiliferous limestone	5 "
Calcareous clay and sand	5 "
Kaolinic quartz sand, containing large pellets of white clay and dessiminated kaolin	15 "
Kaolin, stained with iron oxide near the top of the bed	6 "

The above section was made along the roadway from Deep Creek to the Newsome residence. Inasmuch as but little information could be obtained from the natural outcrops, a number of auger borings were made to determine the extent and thickness of the clay bed. Hole No. 1, bored about 50 yards east of Deep Creek, near the public road and on the south line of the Newsome property, showed:

Kaolinic sand	12 feet
White, plastic clay, stained near the top	7 "
White clay with streaks of yellow and purple	14 "
Cream colored clay, free from "grit"	7 "
Quicksand, water bearing	1 "
Total	41 "

Hole No. 2, located 200 yards north of No. 1, showed:

Coarse kaolinic micaceous sand	10 feet
White, plastic clay, somewhat micaceous	22 "
Very fine, quartz sand, water bearing	2 "
Total	34 "

In hole No. 3, located 200 yards northwest of No. 2, the clay bed was found to have a thickness of 30 feet. The upper 15 feet consisted of white, plastic clay; the lower 15 feet was cream colored and the last 3 feet very sandy.

In hole No. 4, located 50 yards northwest of No. 1, 19 feet of clay was found.

The record of hole No. 5, located on the north line of the property and about ¼ mile north of No. 1, was:

Red, yellow and white quartz and mica sand	18 feet
Tough, yellow clay	2 "
White, micaceous clay	7 "
White, sandy clay	2 "
Tough, white clay	7 "
Total	36 "

The average thickness of the clay bed, as shown by the five auger holes, is 23 feet. While undoubtedly parts of the bed will be found so stained with iron oxide that they will be of but little value, it is believed that the greater part of the bed can be profitably washed, and that there is a large percentage which could be placed on the market without washing.

The possible maximum overburden is 80 feet or more, but this thickness is a gradual increase eastward, and is based of course upon the assumption that the clay bed continues eastward and maintains its thickness. It will be found that an enormous quantity of clay can be mined with an overburden not exceeding 20 to 30 feet.

A sample obtained by the writer from a small pit at the location of auger hole No. 1, was tested in the laboratory. It showed excellent plasticity, and required 45 per cent. of water to develop the maximum. Its linear air shrinkage was 5.8 per cent. Its tensile strength was low, not exceeding 15 pounds per square inch. It is very fine grained, 85 per cent. of the crude or unwashed clay passing a 200 mesh sieve. Under the microscope the sandy impurities observed were, sharp to subangular particles of quartz, flakes of muscovite mica, the most abundant mineral impurity, grains of decomposed feldspar, and the numerous grains of black minerals which are visible to the unaided eye standing out in contrast to the white clay particles. These minerals occur in angular to subangular particles, and no definite crystal forms were detected.

The larger percentage of these large black specks are retained on the 150 mesh sieve. Some of the dark colored minerals recognized under the microscope, were angular particles of smoky quartz, rarely a flake of biotite, while it is probable that a part were grains of hornblende and augite. No magnetite nor titanium bearing minerals could be recognized with certainty. However, some of the quartz particles contain minute black needles which strongly suggest rutile.

Burning Tests

Cone	Fire-Shrinkage	Color
4	5.2%	white
9	10.5%	dull white
12	11.2%	white with black specks
32, vitreous, near fusing point.		

The clay burned steel hard at cone 9, without checking or cracking. The small black specks noted in burning, are due to the fusing of sandy impurities, and would be largely eliminated if the clay was washed. At cone 12, some checking and cracking was observed.

The following is a chemical analysis of the Newsome kaolin:

Moisture at 100° C.	0.44
Loss on ignition, water	11.83
Silica, SiO_2	47.37
Alumina, Al_2O_3	38.06
Ferric oxide, Fe_2O_3	.63
Lime, CaO	trace
Magnesia, MgO	trace
Sodium oxide, Na_2O	.60
Potassium oxide, K_2O	.26
Titanium dioxide, TiO_2	1.37
Sulphur, S	.04
Phosphorus pentoxide, P_2O_5	trace
Total	100.60

Rational analysis:

Feldspar	0.57	Sand	1.05
Quartz	0.48		
Clay substance			98.95
Total			100.00

Several barrels of crude clay from this property were shipped to Augusta and tested for white ware at a small experimental pottery at that place. The results, though made under rather adverse conditions, were promising. The clay should be suitable as a paper filler, as it has excellent slaking properties, plasticity and white color. To obtain clay free from "grit," careful selection from the bed or washing, would be necessary. It is highly refractory and can be used for fire clay products. Excessive shrinkage can be counteracted by a small percentage of sand and the kaolinic sands directly overlying the clay bed would be very suitable for this purpose.

On the property of Wilson Glover, 2 miles east of Gibson, there is a bed of flint fire clay 20 feet in thickness. The bed outcrops at the east end of the Augusta Southern Railroad trestle over Rocky Comfort Creek. It is overlain by 20 to 30 feet of Tertiary sand and clay. A very fine grained aluminous sandstone 2½ to 3 feet thick was noted lying in contact with the flint clay, but this does not seem to be a persistent formation. The flint clay is cream color to yellow, jointed, and contains coarse, angular quartz particles, it is very hard, breaks with an angular or flinty fracture, and disintegrates only very slowly upon exposure to the atmosphere.

A sample ground to pass a 40 mesh sieve when mixed with water, was "mealy," and was very poorly plastic. The air shrinkage was almost inappreciable, and it showed no fire shrinkage until cone 12 was reached, when the total air and fire shrinkage was about 5 per cent. It burns to a cream color and to a yellow. The burned bricklets were very friable, even at cone 16. The air dried tensile strength does not exceed ten pounds per square inch. It is evidently a highly refractory material as it showed no signs of fusing when heated to cone 30. The following is a chemical analysis of this clay:

Moisture at 100° C.	2.28
Loss on ignition, water	10.05
Silica, SiO_2	56.14
Alumina, Al_2O_3	28.39
Iron oxide, Fe_2O_3	1.11
Lime, CaO	.20
Magnesia, MgO	.11
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide, TiO_2	1.84
Total	100.12

Rational analysis:

Feldspar	0.53	Sand	18.37
Quartz	17.84		
Clay substance			81.63
Total			100.00

This clay could hardly be used alone, but when mixed with more plastic clays, should be of value for fire clay prod-

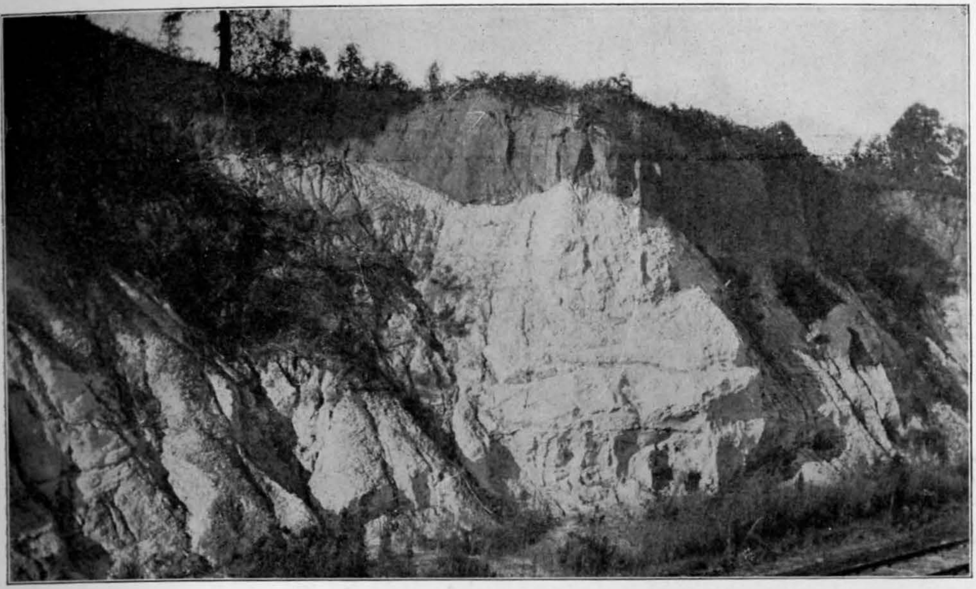


FIG. 1.—CRETACEOUS STRATA AT CARR'S STATION.

FIG. 2.—RAILROAD CUT AT CARR'S STATION.

ucts. The clay bed will likely be found extensive, and may show different texture and physical properties at other points.

At Jumping Gully Creek, about one mile west of Gibson, there is a natural exposure of 10 to 12 feet of semi-indurated white clay overlain unconformably by Tertiary strata, and which seems to occupy the same geological position as the bed of flint fire clay east of Gibson, just described.

On the Grange Road, 4 miles south of Gibson, at Tomkins' Ford on Joe's Creek, there is another natural exposure showing 15 feet of bluish-white or drab, semi-indurated clay. The bed is overlain by 30 feet of greenish Tertiary shale-clay. The clay at this place and at Jumping Gully Creek, will probably be found highly refractory, but does not seem to have any other valuable properties.

AGRICOLA.—On the property of J. T. Brady, 2 miles south of Agricola, 12 feet of white Cretaceous clay was noted; similar clay with an exposure of 10 feet was also noted on Big Creek, 4 miles southeast of Agricola. There are doubtless extensive beds of Cretaceous clays through this region, but none of the outcrops examined, gave promise of being china clays or paper clays.

JEFFERSON COUNTY

Cretaceous strata are exposed only in a very limited area in the northeastern part of this county, and no white clays of importance were discovered during field work. A bed of white clay is reported near the old Lucky Mill on Bigbriar Creek, one mile above Bigbriar postoffice, but nothing is known of its quality. Its distance from a railway line would preclude its being of much value.

RICHMOND COUNTY

Extensive and valuable deposits of fire clays occur in Cretaceous strata in this county. It was not possible during the field work to visit and describe all of the outcrops and deposits in the county, but the following descriptions will be found in the main of general application to other deposits. By reference to the map of the Cretaceous it may be seen in what parts of the county, white burning clays may be expected to be found. The white clays are both hard and soft, and fire clays and kaolins, and in their geological occurrence, structure and origin are quite similar to the clays of the Dry Branch and other regions previously described.

HEPHZIBAH.—Hephzibah is located on the Augusta Southern Railroad, 9 miles southwest of Augusta. One of the most commercially valuable clay deposits in the county, occurs on the property of the Albion Kaolin Company at this place. This clay is being mined, and excellent views of the strata can be seen in the clay pits, and facts concerning the occurrence of the clay of general application, can be observed.

The clay bed is massive, jointed and slickensided. The top of the bed is undulating and the thickness of the bed shows variations. In a moist condition the clay is cream colored to white or light drab; it is soft and in places entirely free from any gritty particles, but may contain small spots of sand and nodules of yellow limonitic clay. In the north side of the pit at the time of my visit, the following section could be seen:

1	At the surface grayish brown sand.............	3 feet
2	Gray and red sand, with small quartz pebbles...	3 to 8 feet
3	Crossbedded clay, arkosic sandstone...........	10 " 15 "
4	Massive, jointed, cream-colored clay............	12 "

The overburden amounts to about 25 feet, though it will present variations in thickness and can reach a maximum of 80 feet. The material above the clay bed, No. 3 of the section, consists of gray, micaceous sand with chunks of kaolin, and may be indurated into a clayey sandstone or arkose, containing the various minerals of granitic rocks. The overburden as a whole is generally unconsolidated.

On the south side of the pit, two clay beds are exposed. The following section was made opposite and about 150 yards distant from the above section, and shows the variable nature of the deposits:

1	Bright, red, fine sand	40	feet
2	Thin layered sandstone	4	"
3	White to grayish hard clay	20	"
4	Crossbedded arkose	10	"
5	Soft, cream-colored kaolin	4	"

The hard clay, No. 3 of this section, does not appear on the north side of the pit. This hard clay grades abruptly into a coarse kaolin sand and a hard kaolin breccia or sandstone.

The sand, No. 4, varies in thickness from 3 to 20 feet within a horizontal distance of 150 feet. Only 4 feet of the soft kaolin at the bottom of the section is exposed, but the bed is reported to have a thickness of 9 feet. This soft clay bed corresponds in its geological position to the soft clay bed being mined on the opposite side of the pit.

The hard clay or flint fire clay, No. 3 of the last section, warrants special description. It differs from the soft kaolin in hardness, texture and physical properties, but does not differ materially in chemical composition aside from the greater percentage of quartz sand. It presents minute joining and is stained both by iron and manganese along the joint planes. The sand grains are notably larger in size than in the soft clay, some being found as large as a pea and one-fourth inch in diameter. Stem like and round nodules of clay occur within the mass of clay and weathering out, leave a pitted surface. These pits and worm like holes may contain black incrustations of manganese dioxide, pyrolusite. Upon exposure to the weather, the clay crumbles, and large chunks fall from the bed and form debris at the bottom of the pit.

The clay on this property undoubtedly occurs in enormous quantity, and at the present rate of mining, will last many years. Outcrops of the clay occur in the valley, both above and below the present pit, and the bed shows no indications of diminishing in thickness, as it is worked back into the hill. Beyond actual observation, however, the thickness and purity of the clay beds can not be predicted with certainty, as both purity and thickness are liable to variations.

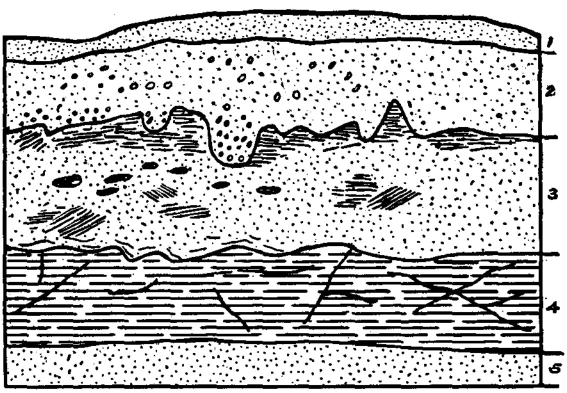


Fig. 8.—Sketch of the Clay Pit of the Albion Kaolin Company, Hepzibah, Georgia. 1. Superficial Sand (Columbia). 2. Red Sand (Tertiary). 3. Coarse Kaolinic Sand (Cretaceous). 4. White Clay Bed. 5. White Micaceous Sand.

Samples of both the hard and soft clays were collected and tested in the laboratory. The following is a chemical analysis of the soft clay. The analysis represents probably the average of the whole thickness of the bed from the pit from which it was taken, and does not represent the purest selected clay.

Moisture at 100° C	0.55
Loss on ignition, water	12.42
Silica, SiO_2	44.99
Alumina, Al_2O_3	38.59
Iron oxide, Fe_2O_3	2.11
Lime, CaO	trace
Magnesia, MgO	0.05
Manganese dioxide, MnO_2	trace
Soda, Na_2O	0.24
Potash, K_2O	0.11

Titanium dioxide, TiO_2	1.04
Phosphorous pentoxide, P_2O_5	.13
Sulphur, S	.02
Total	100.25

Rational analysis:

Sand	5.51
Clay substance	94.49
Total	100.00

A sample of the purest clay, when tested in the laboratory, showed almost entire absence of any gritty particles, was of a rich cream color, and very plastic. It required 42 per cent. of water to develop its best plasticity; its tensile strength was low, not exceeding 12 pounds per square inch. Its air shrinkage was 4.3 per cent.; slaking properties excellent, ranking in this respect as one of the best clays tested. It was very fine grained, 98 per cent. passing a 200 mesh sieve, or in other words 98 per cent. of the component grains were less than .0025 of an inch in diameter.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
4	5.2%	pure white	soft
12	12.4%	faint cream	steel hard

The clay exhibits a slight cracking in burning. Notwithstanding that this clay shows a higher iron percentage and is a darker color in its raw state, it burns whiter than other clays, showing smaller iron content and whiter color. The clay is highly refractory; tested in the Deville furnace its fusing point was determined at cone 34.

This soft clay is mined and used extensively as a filler for wall paper and newspaper, and its suitability for these purposes has been demonstrated. In addition, the selected and purest clay gives promise of being of value as an ingredient of white ware bodies, though no tests on a commercial scale have yet been made. Its fine plasticity and working qualities would be much in its favor, though from present knowledge, it could be used only in limited quantities on account of its off color when burned at a high temperature. The faint cream color does not seem to be developed until a temperature above cone 4 is reached, since at this latter temperature it burned pure white. In the lower grades of pottery where pure white colors are not requisite, it should be a valuable clay.

The more impure parts of the bed are high grade fire clays and could be used in the manufacture of fire brick and other refractory products.

Physical Tests on Flint Fire Clay from Albion Kaolin Company Hephzibah

The plasticity of the clay is poor and it tends to be "mealy," owing to its very poor slaking qualities. Its tensile strength is low on account of the coarseness of the clay particles. In color it is perhaps somewhat lighter than the soft kaolin. It showed an air shrinkage of 5 per cent.; the fire shrinkage was lower and its tendency to check in burning was less than in the soft clay. The burning tests were:

Cone	*Fire-Shrinkage*	*Color*	*Condition*
4	4.4%	white	soft
15	9.1%	cream	cracked

This clay was unfused at cone 33, 3,254°F, and may therefore be considered, in point of refractoriness, a No. 1 fire clay. In connection with the soft clay it might be used in the manufacture of fire brick and other refractory wares.

Method of Mining at Albion Kaolin Company's Pits

The method of mining is similar to that described at Dry Branch. Mining is carried on in open pits, and this seems to be the only practicable way of mining, since the strata overlying the clay bed consists for the most part of unconsolidated sand which would not permit of sinking a shaft and employing underground methods.

A small roughly circular or square pit is started near the level of the outcrop of the clay bed where the overburden is least. The overburden is first entirely removed from the top of the bed so that an area of 300 or 400 square feet of clay is laid bare. This overburden is entirely waste and is usually dumped at some point where it will not interfere with future mining. The overburden being removed, the kaolin is excavated to the depth that is desired to work the bed, and a vertical clay "breast" or "face" is made, from which the clay is more easily picked down.

The kaolin is too tough to be spaded, and it is pulled down from the clay face in large chunks by the use of broad pointed curved picks. Two miners drive their picks deep into the clay face at points a few inches apart, and by combined prying tear off large chunks of clay. Jointing greatly facilitates mining, and frequently heavy wooden stakes are driven into the top of the clay bed a foot or so back from the clay face, and to such a depth that oblique or horizontal joint planes are intersected, when large chunks of kaolin may be thus pried off, the chunks slipping along the joint surfaces which are usually slickensided and quite smooth. The clay chunks are broken up and culled and sorted. The pits are kept free from water by drainage ditches and by pumps. Usually a shallow ditch is dug on the top of the clay bed to divert the water which seeps through the overlying sand.

The chunks of raw kaolin are loaded by hand on small cars at the pit, and hauled to the air drying shed. The drying shed is situated on the hill, 80 feet above the pit and the loaded cars are pulled up an incline by means of a steam hoist. The drying shed is a long covered shed with open sides to allow circulation of air through the clay. The shed consists of a series of superimposed racks, the floors of which are movable and are made of poles or 2x4 scantlings placed a few inches apart. The vertical interval between the racks is 4 or 5 feet. The "green" clay is dumped on the top rack and as it dries is dumped on the racks below until it reaches the floor of the shed. Under ordinary conditions of weather about three weeks are required for drying. The dry clay is broken up into small chunks and packed by hand into large wooden casks holding approximately a long ton.

King Property.—On the King estate in Richmond county, 2½ miles south of Belair, and 5 miles southeast of Grovetown, there is a fine natural exposure of Cretaceous clay. The clay bed outcrops in the hill and the east side of a small stream which flows through the property, and can be located by springs which issue from the contact between it and the overlying loose sand. The clay is semi-hard, white and for the most part contains a large percentage of coarse, quartz sand. At two points where the bed was prominently exposed, it showed a thickness of 15 and 18 feet. The following geological section of the hill shows the nature of the overlying and underlying beds. The section was made from the house westward down the hill to the main spring:

1	Slope, covered by a mantle of loose sand	20 feet
2	Red and orange loose sand	40 "
3	White clay	18 "
4	Sand with pebbles and white clay layers	30 "
5	Sand to creek, character concealed	50 "

About one half mile south of the spring and the principal exposure of the white clay, a bed of soft, white kaolin 4 feet thick is exposed in the hillside, and occupying about the same position as the hard bed. The hard clay is not exposed at this point. It is probable that the beds will be found here as elsewhere, variable in texture and thickness.

A sample of this clay was collected and tested in the laboratory. It must be borne in mind that the property is entirely undeveloped, and the tests here given are indicative

GENERAL VIEW OF THE CLAY PITS OF THE ALBION KAOLIN COMPANY, HEPZIBAH, RICHMOND COUNTY, GEORGIA.

only of the part of the bed which is naturally exposed. The following is a chemical analysis of a sample representing as nearly the average of the bed as was possible under the circumstances:

Moisture at 100°C	2.69
Loss on ignition, water	11.53
Silica, SiO_2	48.87
Alumina, Al_2O_3	33.41
Iron oxide, Fe_2O_3	1.11
Lime, CaO	0.00
Magnesia, MgO	.09
Soda, Na_2O	.31
Potash, K_2O	.41
Titanium dioxide, TiO_2	1.65
Sulphur, S	.09
Total	100.16

Rational analysis:

Fluxing impurities	1.92
Sand	19.82
Clay substance	80.18

Physical Tests

Slaking property	poor
Plasticity	medium
Tensile strength	very low
Air shrinkage	5.8%
Cone 5—	
Fire shrinkage	4.9%
Color	dull white or gray
Condition	soft
Cone 12—	
Fire shrinkage	10.1%
Color	cream
Condition	soft, slight check'g
Refractoriness	unfused at cone 33

This clay is evidently unsuitable for white ware pottery or for the purpose of the paper manufacturer, but might be used for fire brick, and buff and white ornamental building brick, and possibly as ingredients of stoneware and terra cotta mixtures.

O'Connor Hill Clay.—This deposit is located on the old Blackstone place, one mile south of 18 mile-post, on the Georgia Railroad. Several years ago a small pit was sunk here and a small quantity of clay mined and shipped. The clay is white, semi-hard, and free from any large percentage of sand. The following is a geological section of the hill in which the bed occurs:

	Feet
Sand, slope covered with iron ore fragments	10
Bed of siliceous iron ore	2 to 4
Gravel	3
Yellow and brown sand with thin clay layers	50
White clay	12
Kaolinitic sand	40

The overburden is rather excessive, and the hill being quite steep, a great thickness of sand would have to be removed from the start. The overburden is unconsolidated with the exception of the thin bed of iron ore shown in the above section. The underlying material is a gray or white sand containing thin layers of disseminated kaolin.

The main bed of clay is semi-hard, and part of it shows a pitted surface due to the weathering out of darker colored clay nodules. The bed gives some evidence of thinning out to the northward, though doubtless the quantity of clay is sufficient for any commercial purposes. A small amount of this clay has been used at the plant of the Georgia Vitrified Brick and Clay Company at Campania, and is said to have given satisfactory results.

Physical Tests on White Clay from O'Connor Hill

Color	white to cream
Hardness	semi-hard
Plasticity	very good
Slaking	poor or not at all
Tensile strength	15 lbs. per sq. in.
Air shrinkage	4.1%
Cone 4—	
Fire shrinkage	8.6%[1]
Color	white
Condition	checked badly
Hardness	soft, friable
Cone 9—	
Fire shrinkage	11.1%
Color	white to cream
Condition	slightly cracked
Hardness	soft

1. Measurement not accurate on account of cracking.

Cone 13—

Fire shrinkage	11.1%
Color	cream
Condition	badly cracked
Refractoriness	unfused at cone 33

The following is a chemical analysis of this clay:

Moisture at 100° C	4.95
Loss on ignition, water	13.18
Silica, SiO_2	43.13
Alumina, Al_2O_3	36.34
Ferric oxide, Fe_2O_3	.79
Lime, CaO	0.00
Magnesia, MgO	.02
Soda, Na_2O	.19
Potash, K_2O	.07
Titanium dioxide, TiO_2	1.47
Sulphur, S	.10
Phosphorus pentoxide, P_2O_5	.06
Total	100.30

Rational analysis:

Feldspar	1.47	Sand	2.13
Quartz	.66		
Clay substance			97.87
Total			100.00

This clay has good plasticity when finely ground, and with its high refractoriness should be suitable for fire brick and other refractory products, though when used alone it will perhaps exhibit a tendency to crack in burning. This tendency to crack in burning can be overcome by mixing a small percentage of sand with the clay; the clayey sand of the Cretaceous lying beneath the bed would be suitable for this purpose. It does not give much promise of being suitable for white ware pottery, though its quality would doubtless be greatly improved by fine grinding and washing.

Sandy Run Creek.—Along Sandy Run Creek in the southwestern part of the county, considerable thicknesses of hard, white fire clays were observed. These clays are inaccessible at present, but may be of future value.

Belair.—There are a number of exposures of Cretaceous strata in this vicinity, but little white clay of commercial importance was noted. The Cretaceous is here quite thin, and can be seen lying upon the upturned edges of beds of metamorphic schists. Northward from Belair only igneous and metamorphic rocks are exposed. The above mentioned schists have proved to be of economic importance in connection with the white clays, and will be discussed later.

At mile-post 8, on the Georgia Railroad, there is a cut about 15 feet deep in which white clay layers as much as 4 or 5 feet in thickness, may be seen, but these do not seem to be extensive, and the clay does not give promise of being of especial quality, though it is doubtless highly refractory.

In prospecting for white clays, it will generally be found that the soft, plastic clays, as at Hephzibah, are most likely to be of value, as pottery and paper kaolins, rather than the hard and semi-hard clays described from O'Connor Hill and the King place.

Augusta.—During the progress of the Georgia-Carolina Fair at Augusta in 1906, a small test pottery was in operation for the purpose of demonstrating that good white ware could be made from the white burning, plastic, sedimentary clays of the Cretaceous of Georgia and South Carolina. The kiln was updraft, 6 feet in diameter and 10 feet high, and had a capacity of 175 dozen cups and saucers. The machinery consisted of an upright pug mill, a small blunger, a 22-chamber filter press, a slip pump, glaze mill, ball mill, one jigger and one lathe. The machinery was operated by an electric motor. The ware was burned to cone 9, and about 30 hours were required for burning. The potter, though working under adverse conditions and with insufficient assistance, succeeded in turning out creditable hotel china.

COLUMBIA COUNTY

The greater part of Columbia county lies within the Crystalline belt of rocks, and only a small area, in the southeastern part of the county in the vicinity of Grovetown and Harlem, is underlain by Cretaceous and Tertiary strata, and contains the deposits of white clays which come within the scope of this part of the report.

GROVETOWN.—About one fourth mile east of the railroad station at Grovetown, on the Fisk property, there is a deposit of semi-hard fire clay reported to be 10 feet in thickness. This bed is overlain by 4 feet of soft plastic clay which has been used for stoneware in the old Grovetown pottery. The clay bed is evidently of Cretaceous age, and is overlain by a Tertiary fuller's earth deposit. The stoneware clay seems to grade into the indurated fire clay. It is very plastic and has a high fusing point, and has been used to some extent in lining the cupolas at the Lombard foundry in Augusta.

Physical Tests on the Grovetown Hard Fire Clay

Plasticity	fair
Tensile strength	15 lbs. per sq. in.
Air shrinkage	5.1%
Drying qualities	good
Cone 5—	
Fire shrinkage	3.7%
Color	white
Condition	very soft
Cone 13—	
Fire shrinkage	7.2%
Color	buff
Condition	dense body without cracking

The following is a chemical analysis of a sample from the upper four feet of the bed.

Moisture at 100° C	1.94
Loss on ignition, water	8.95
Silica, SiO_2	60.44
Alumina, Al_2O_3	25.75
Iron oxide, Fe_2O_3	1.27
Lime, CaO	0.00
Magnesia, MgO	.04
Soda, Na_2O	.14
Potash, K_2O	.43
Titanium dioxide, TiO_2	1.14
Phosphorus pentoxide, P_2O_5	.14
Total	100.24

Fluxing impurities	1.88
Sandy impurities	30.73
Clay substance	69.27

This clay alone or mixed with other clays should be suitable for fire brick and other refractory products. It might be used in the manufacture of buff or cream colored building brick and in stoneware mixtures, but is unsuitable, alone, for stoneware on account of its high vitrifying point.

Seventeen Mile-Post, Georgia Railroad.—There are 4 to 5 feet of white, plastic clay, expósed in a ravine to the north of the railroad, at this point, overlain by unconsolidated, pebbly sand. Some effort has been made by prospectors to trace the bed westward, but without success. It would seem that the clay is merely a small lens, and does not occur in large quantity. The following tests are given by Ladd[1]:

Tensile strength 25 pounds per square inch; fusing point between Seger cones 35 and 36.

Railroad Cut East of Grovetown.—In a railroad cut about a mile east of the station at Grovetown, 5 feet of stained kaolin is exposed. The clay is mottled purplish and white, and this staining would detract from its value for high grade clay wares. The clay, however, might be used as a fire clay. The bed seems to be lens shaped, and it is doubtful whether it is of large extent.

Campania.—At this place is located the plant of the Georgia Vitrified Brick and Clay Company. This company manufactures vitrified brick, sewer pipe and fire brick. The clay used is a mixutre of Tertiary plastic clays found at the plant and decomposed schist from Belair. A hard fire clay of the Cretaceous has been used in the manufacture of fire brick. It will be found that some of the clays here differ considerably from those heretofore described, since they belong to the Tertiary formation. While this part of the report is deal-

1. Ga. Geol. Surv. Bull., 6—A, p. 165.

ing primarily with the Cretaceous fire clay and kaolins, the clays of the two systems are so closely associated at this place that it is thought best to describe the Campania deposit here.

The following is the succession of beds exposed in the pit to the west of the plant:

1	Yellow pebbly sand, overburden	8 feet
2	Yellow and white variegated clay	5 "
3	White sandy clay	7 "
4	Black, carbonaceous, jointed clay	4 "

These clays differ from the Tuscaloosa white clays, in that they are laminated and not massive bedded, and in that they show frequently a high percentage of organic matter, and are less refractory.

In a pit about 100 yards northeast of the plant, 12 feet of Cretaceous fire clay is exposed. The upper 4 feet is a white flint clay containing coarse angular particles of quartz; while the lower 4 feet is softer and more iron stained. The clay is similar to that at Grovetown and O'Connor Hill. A sample tested in a Deville furnace was not melted at cone 30 and did not even show complete vitrification at this temperature. When used alone it shows a tendency to crack badly in burning. This defect is common to most of the white clays of the Fall Line belt, and can be overcome by calcining or by mixing in sand or other non-plastic material.

HARLEM.—The following interesting exposure of clay and sand may be seen at Phillips Falls, 1½ miles southwest of Harlem:

1	Red Tertiary sand	10+	feet
2	Blue to gray thin bedded clay-shale	20 to 30	"
3	Interstratified sand and clay	3	"
4	Massive gray to bluish-gray, hard clay	10	"
5	Sand containing large chunks of kaolin and disseminated kaolin	10+	"

Beds, No. 2 and 3, are in the same geological position as the fuller's earth deposit at Grovetown. No. 4 will be found highly refractory and is the top of the Cretaceous beds and is in the same geological position as the hard fire clay beds described at Grovetown and in Richmond county.

McDUFFIE COUNTY

The southern portion of this county, or that part lying south of the Georgia Railroad, is within the province of the Coastal Plain. The geology of the county is similar to that of other counties lying along the Fall Line in the eastern part of the State. The surface is covered by a thin mantle of gray or brown loose sand, which is underlain by the red sand and light colored clays of the Tertiary. Beneath the Tertiary, wherever erosion has been active, is exposed the coarse kaolin sand of the Tuscaloosa, and in places the streams have frequently cut through or entirely removed the sediments, and exposed the crystalline or igneous rocks.

Thomson.—On the Shields property, one mile east of the station at Thomson, there is a bed of white, sandy fire clay, reported to be 10 feet in thickness. Some attempt was made by local capitalists to develop this property with the intention of manufacturing ornamental building brick, and some of the clay was burned in a small test kiln at Grovetown with good results. There is no reason why this and numerous other deposits of white and stained clays could not be used for ornamental building brick when intelligently handled. Whether market conditions and manufacturing facilities justify the establishment of plants are points for the investor himself to determine.

Brinkley Plantation.—On the plantation of Ira Brinkley, 3 miles southwest of Dearing, 16 feet of stained kaolin is reported to have been found in a well. The clay is white with pink or purplish stains of iron oxide, soft, and some quite free from sandy impurities. Nothing is known as to the areal extent of the bed, and no natural exposures were found. The following are physical and chemical tests made on a sample of this clay:

Physical Tests on Brinkley Clay

Color	white to pink
Hardness	soft, friable
Texture	fine grained
Plasticity	good
Tensile strength	very low
Air shrinkage	4.1%
Cone 4—	
Fire shrinkage	6.5%
Color	white
Cone 8—	
Fire shrinkage	10.7%
Color	cream
Hardness	steel hard
Cone 13—	
Fire-shrinkage	11.1%
Color	cream to buff
Condition	cracked
Refractoriness	unfused at cone 30

Chemical Analysis of Brinkley Clay

Moisture at 100° C.	.60
Loss on ignition, water	12.15
Silica, SiO_2	49.21
Alumina, Al_2O_3	35.07
Iron oxide, Fe_2O_3	1.53
Lime, CaO	0.00
Magnesia, MgO	0.00
Soda, Na_2O	.04
Potash, K_2O	.30
Titanium dioxide, TiO_2	1.61
Total	100.51
Fluxing impurities	1.87

Rational analysis:

Feldspar	.60	Sand	9.54
Quartz	8.90		
Clay substance			90.46
Total			100.00

The bed as a whole would probably burn to too dark a color to be of value as a pottery kaolin, and its slightly pink color and staining in the raw state makes it rather unfavorable for paper filling. It may be possible to select the purer parts of the bed, and the clay could be greatly improved by washing. The clay might be used in refractory clay products. The above tests may be taken in a measure to indicate the nature of other stained clay deposits occurring in the county.

OTHER LOCALITIES.—Three miles west of Dearing, on the Milledgeville public road, at a point known locally as "Chalk" hill, a bed of soft, plastic, white clay was noted. The clay is apparently good in quality, and about 6 feet is exposed. Nothing is known as to the extent of the bed, but the overburden is not excessive, and the quantity of clay could be easily determined by auger boring at points along the hill side, at about the level of the outcrop in the road.

About one half mile west of the above locality, 30 feet of "chalk" or white clay was reported as having been found in a well on the property of C. C. Ansley. The clay thrown from the well was, for the most part, white and contained only a small percentage of sand. The bed was found 30 feet from the surface, and if it is of large extent, areally can probably be found along the hillside to the west of the well or at other points nearby, which are approximately 30 feet lower than the surface at the well.

Throughout the southeastern part of the county, along Boggy Gut, Headstall and Brier creeks, there are numerous exposures of white clay in Cretaceous strata. Both hard or flint and soft clays are found, and will generally be found to have high refractoriness; but the iron staining which is present, precludes their use as china clays or paper clays. On the T. J. Connell property, and the J. F. Whitaker property, 4½ miles south of Harlem, a bed of indurated white clay was noted. This clay is quarried and used locally for chimneys and foundations, and is similar in appearance to that in Wilkinson county previously described on the Carswell and Miller properties. The clay in this part of McDuffie county is at present so far removed from transportation lines that it is of little value.

Good exposures of Cretaceous strata and some thin clay beds may be seen in the cuts of the Georgia Railroad near Boneville and Dearing. No clays likely to be of commercial importance were noted, and the cuts are only of interest from the purely geological standpoint.

A sample of soft, iron-stained clay from the T. J. Connell property, 4½ miles south of Harlem, showed the following physical properties:

Color	white with iron oxide splotches
Hardness	soft, friable
Plasticity	good
Tensile strength	20 lbs. per sq. in.
Air shrinkage	5.8%
Cone 5—	
Fire shrinkage	5.4%
Color	pink or lavender
Condition	steel hard
Cone 8—	
Fire shrinkage	10.2%
Color	buff

The clay is too impure to be of any value for white ware pottery.

WARREN COUNTY

There are some Cretaceous beds underlying the southern part of this county, but with the possible exception of a small area in the extreme southeastern part of the county, they are very thin, and no kaolins or fire clays of importance are known to occur.

HANCOCK COUNTY

The greater part of this county was probably originally covered by the Coastal Plain sediments, but they have been almost entirely removed by erosion, and only areas in the southern and western part of the county remain. There are no clay industries in the county, and the only important clay deposit known, is at Carr's Station on the Georgia Railroad.

CARR'S STATION.—In a deep cut of the Georgia Railroad at this place, there is one of the most interesting and instructive exposures of Cretaceous strata to be seen along the Fall Line. The cut in the deepest place is 50 feet deep, and the full thickness of the Cretaceous deposition at this point may be observed. The kaolinic and arkose sands rest upon decomposed crystalline rocks and are overlain by a thin mantle of loose, brown sand of Pleistocene age. The small lens shaped beds of kaolin so peculiar to the Tuscaloosa strata are exposed entire, imbedded in a mass of kaolinic sand; that is, the whole vertical and horizontal extent of a clay bed may be seen.

There is a small clay pit here, and a small amount of fire clay has been mined and shipped to various points in the State. About 8 feet of clay is exposed in the pit, and the bed is perhaps some thicker. It is overlain by loose, red sand, 4 to 15 feet in thickness. The clay is jointed, and there is some iron oxide staining along the joints which has been deposited by waters which have filtered through the overlying red sands, and have carried iron oxide particles in suspension. The clay is a drab or gray color when moist, becoming white when dry. It is very free from quartz sand, but contains a large percentage of minute muscovite flakes. This individual bed is not of large extent areally, and is seen to grade into a micaceous, kaolinic sand about 100 feet west of the pit.

The following very interesting geological section occurs on the north side of the first cut west from the railway station. The different beds here are not continuous or persistent in texture and structure, and a section 100 feet distant from the one given, might be quite different.

		Feet
1	Red to brown sand, with white clay pellets and thin clay layers	5
2	Red to brown, crossbedded sand	10
3	Breccia of white clay and partly cemented red sand	4
4	Kaolin bed	6
5	Fine, white, kaolinic sand	10
6	Augular, quartz gravel and arkose	5

The kaolin bed, No. 4, has been eroded subsequent to its deposition, and the white clay of the overlying breccia was probably in part derived from it. The bed shows variations in thickness, and is seen to grade into and to be entirely replaced by the kaolinic sand underlying. This clay bed does not appear on the south side of the cut a few feet opposite, proving the inconstancy of Tuscaloosa deposition. The sand of No. 5 is composed mainly of quartz and muscovite mica, with a high percentage of kaolin disseminated through the mass. There is very little staining from iron oxide, and the whole could be washed for the kaolin. The upper 20 feet consists of fine sand with clay pellets or fragments, and is colored brown or red by iron oxide. The clay in the second cut is generally very sandy, but pockets of clay may be found as pure as that in the first cut. At the ends of the cut, the red and white sands grade imperceptibly into each other. A rough estimate of the amount of kaolin, in beds and disseminated in the lower 30 feet in the cut, is 40 per cent. The greater part of the sand could be separated by washing, but some muscovite and sericitic mica, being in such minute flakes, would float off with the clay. This mica will exert some fluxing action, but will not affect the burned color of the clay.

A sample of clay was selected from the first cut and represented as near as was possible, the average of the bed. The following is a chemical analysis of the unwashed clay:

Moisture at 100° C	0.58
Loss on ignition, water	12.24
Silica, SiO_2	44.76
Alumina, Al_2O_3	39.34
Iron oxide, Fe_2O_3	1.11
Lime, CaO	.08
Magnesia, MgO	.07
Manganese oxide, MnO	trace
Soda, Na_2O	.42
Potash, K_2O	.71
Titanium dioxide, TiO_2	1.20
Total	100.51

Rational analysis:

Sand and mica	11.77
Clay substance	89.23
Total	100.00

The clay was very plastic, and required 31 per cent. of water for mixing. The air shrinkage was 6.3 per cent.; the tensile strength, low, not exceeding 12 pounds per square inch. The clay is soft and very fine grained; 81.6 per cent. passed a 150 mesh sieve, and 70 per cent. passed a 200 mesh sieve.

Its slaking properties are good, but it does not remain in suspension as readily as some other kaolins tested. The sandy impurities as determined under the microscope, consist of muscovite mica, quartz, partly decomposed feldspar, and minute particles of black minerals probably, hornblende or pyroxene, biotite and ilmenite.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	6.3%	white
12	13.1%	faint cream

The clay burns steel hard at cone 4, with but little checking. Its fusing point is cone 33. This clay gives some promise of being suitable for white ware pottery and for paper filling, though to be successful for these purposes, a washing plant would have to be installed. The property is advantageously located with reference to transportation facilities, and water for power and washing purposes can be secured nearby.

BIBB COUNTY

This county, though located in the center of the white clay belt, and having valuable clays both to the east and west of it, does not itself contain any known deposits of kaolin or fire clay of much commercial importance. Only the southern half of the county is underlain by Coastal Plain sediments, and it is only in this part of the county that valuable white clay deposits are to be expected.

In the cuts of the railroads, going east from Macon, good exposures of white clayey sands may be seen, but the amount of clay is small and, though in populous communities less favored with clay resources they would likely be utilized, they are of no value here on account of the enormous quantity of pure clay at Dry Branch and other localities.

A typical occurrence of these clayey sands may be seen in the cut of the abandoned Macon and Augusta Railroad, 3 miles east of Macon.

At a point on the Lower river public road, 5 miles below Macon, 6 feet of white clay is exposed in a cut. It is overlain by a red sand containing thin clay layers and fragments of white clay, and is underlain by white micaceous sand. This clay will be found highly refractory, but it is doubtful whether the bed is of large extent, or that the clay occurs in any great quantity.

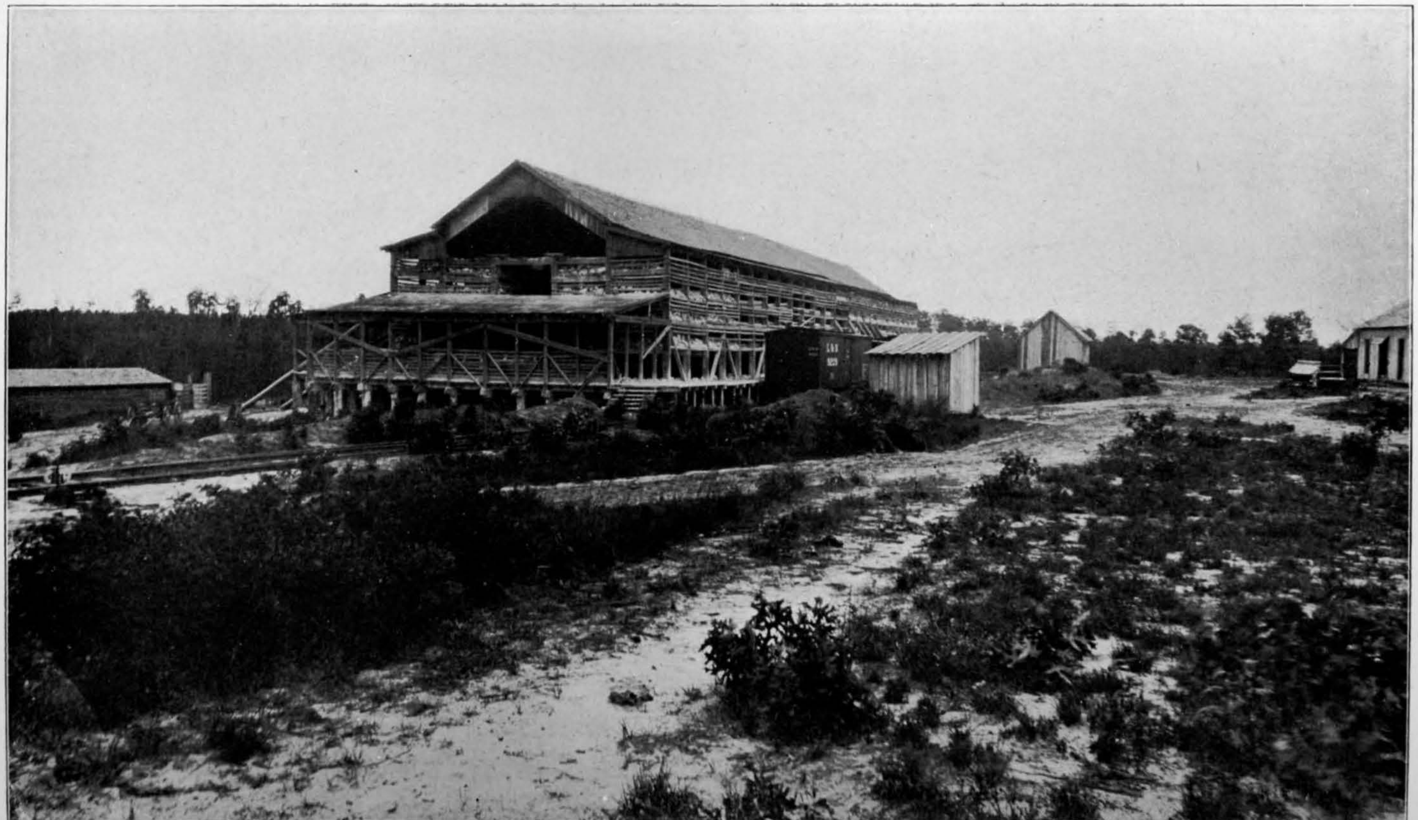
At Brown Mountain in the southern part of the county, 9 miles from Macon, 110 feet of white, clayey sand is exposed at the base of the hill. This sand is Cretaceous, (Tuscaloosa) and contains thin layers and fragments or pellets of white, pure clay, but no thick beds of kaolin have been found. About two miles south of this point on the Tharpe estate, white clay has been found at the base of a fuller's earth deposit, but as far as the writer knows, no effort has been made to determine its quantity. A small sample tested in the laboratory showed good plasticity, and air-dried strength of 82 pounds per square inch; air shrinkage, 8 per cent.; it burned white at cones 4 and 9; and to dense bodies without cracking. It shows valuable properties and is worth further investigation.

In the western part of the county, along Echaconne Creek, beds of white clay will be found in the Cretaceous sands. But little or no prospecting for clay has been done in this part of the county, and but little is known, concerning these deposits. Judging from the few observations made during field work, the beds are likely to be thin, and stained with iron oxide.

Macon, the largest city of Central Georgia, is located in this county. The clay industry at this place is confined to the manufacture of common building brick and sewer pipe, and only the alluvial clays of the Ocmulgee River are used. With its excellent transportation facilities and the abundance of white clays in the adjoining counties of Twiggs, Jones and Houston, this city should become a center for the manufacture of white ware, sanitary ware, electrical porcelain, etc., and fire clay products. The fact that such industries have not already been established, seems to be due to a general skepticism among local capitalists, concerning the possibilities of the clays for such purposes, and lack of knowledge concerning the extent and quality of the clays by outside investors.

HOUSTON COUNTY

Heretofore the descriptions of the Cretaceous clays have been confined to the counties lying east of the Ocmulgee River, or to the eastern belt of the Cretaceous and the Fall Line white clays. The clays in the eastern belt were confined to Lower Cretaceous or Tuscaloosa strata. In the western belt of the Cretaceous, the geology of the clays is different and pockets of white clay are found in a great thickness of Upper Cretaceous colored sands lying above the Tuscaloosa. The Tuscaloosa maintains in a general way, the character of the eastern belt, but the clays that it contains will upon the whole, be found less extensive and less pure than in the eastern belt, though there may be exceptions to this in a few localities. The semi-hard and flint fire clays so common between Macon and Augusta, are rarely observed west of the Ocmulgee.



DRYING SHED OF THE ALBION KAOLIN COMPANY, HEPZIBAH, RICHMOND COUNTY, GEORGIA.

In Houston county notable deposits of white clays were observed in the vicinity of Perry, Fort Valley and Byron. With the exception of clay mining at Perry, there are no clay industries in the county, and the clay deposits are undeveloped.

PERRY.—A deposit of kaolin occurs on the Yancey property, on Bay Creek, 2 miles northwest of Perry. This clay was described by the writer in Bulletin 315 of the United States Geological Survey, but since the above description was written, a small mine has been opened up, and the property to some extent developed. Before the pit was opened up, the property was prospected, and white clay was found at a number of points over an area of 500 acres, and the probability of both quantity and quality, seemed fairly assured. Since opening up a pit, excellent clay has been found, though the staining by iron oxide has been more considerable than was anticipated. It is likely, however, that the clay will be found purer as the bed is worked back into the hill. The clay bed at the point mined, has shown a maximum thickness of 18 feet. The clay is soft, massive bedded and jointed, though the jointing is not as extensive as in the Dry Branch region, and slickensided surfaces along the joint planes were not observed. The bed upon the whole is very free from sandy impurities, but it may grade into or be replaced by sand, and may be split by sand layers. At the top of the bed where it lies in contact with the overlying ferruginous sands, staining is observed to penetrate the clay, but at the middle and bottom of the bed, it is confined to the joints. As a result of the staining, it is necessary to carefully cull or cut out the impure parts.

The overburden consists of very fine, variegated, quartz and micaceous sands, which will show a maximum thickness of about 80 feet. The whole is unconsolidated, and could be easily moved by a steam shovel. The slope of the ridge to

Bay Creek is steep, and the overburden increases in thickness very rapidly.

The property is accessible to the Central of Georgia Railroad and water for power or washing purposes, can be obtained from Bay Creek.

Physical Tests on Kaolin from Perry

The following tests were made upon a sample of the purest clay from this locality. The sample, however, was unwashed and had received no mechanical treatment.

Color	white to cream
Hardness	soft, friable
Slaking	good
Plasticity	very good
Tensile strength	15 lbs. per sq. in.
Air shrinkage	4.9%
Cone 5—	
Fire shrinkage	6.8%
Color	white
Condition	checked
Cone 9—	
Fire shrinkage	11.8%
Color	faint cream
Condition	cracked
Cone 12—	
Fire shrinkage	13%
Color	cream
Cone 16—	
Color	bluish gray
Condition	cracked badly
Fusing point	above cone 33

The following is a chemical analysis of this clay:

Moisture at 100° C.	1.47
Loss on ignition, water	13.58
Silica, SiO_2	44.86
Alumina, Al_2O_3	37.34
Iron oxide, Fe_2O_3	.56
Lime, CaO	trace
Magnesia, MgO	.05
Soda, Na_2O	.04
Potash, K_2O	.22
Titanium dioxide, TiO_2	1.66
Total	99.78

Rational analysis:

Feldspar	1.612	Sand	1.94
Quartz	.328		
Clay substance			98.06
Total			100.00

The above analysis shows a very pure clay, and the percentage of iron oxide is small. The clay gives promise of being suitable for white ware pottery, though no tests on a commercial scale have been made. A mixture made in the laboratory by the writer, consisting of:

Perry kaolin (unwashed)	40%
Dry Branch (bonding clay)	20%
Spar	20%
Flint	20%

gave good results when burned at cone 9. The raw mixture had good plasticity and high tensile strength; burned, it gave a white color, and dense body without checking. It is not presumed that the above mixture would be successful in practice, it might or might not be; the object was to ascertain the properties of this clay when burned in a mixture with potters flint and spar.

The clay slakes readily in water, but does not fall into a finely divided condition, but rather into small angular lumps. In this respect it is somewhat inferior to the Dry Branch and Hephzibah clays.

In point of refractoriness, it is a No. 1 fire clay, having a fusing point above cone 33, 3,254° F.

A pocket of white clay was noted on the Macon road, 5 miles northeast of Perry. The clay is exposed in a gully along the public road near the crossing of Mossy Creek. The deposit, owing to its inacessibility, is of no value at present, but is instructive in showing the geological occurrence of the white clays of the Upper Cretaceous (?). The deposit is lens shaped or cigar shaped, having a maximum thickness in the center, and tapering at each end; the full extent of the bed can be observed. The bed is about 100 feet in length, and has a maximum thickness of 8 feet and is overlain and underlain by red sand. Doubtless numerous other outcrops of white clay may be found eastward from Perry.

FORT VALLEY.—A clay deposit, located about 1½ miles south of this place, on the Perry branch of the Central of Georgia Railroad, was examined, and sampled during field work. The clay is exposed in gullies on both sides of the track, and shows thicknesses of 5 to 13 feet. It is a drab or bluish gray in color, and is often fantastically mottled red, yellow and white; it also varies in texture, becoming in places quite sandy. The deposit is undeveloped, and as far as the writer is aware, no prospecting has been done to determine the extent of the bed.

The following are physical tests made on a sample of this clay:

Color (dry)	cream
Hardness	soft, friable
Slaking	good
Plasticity	very plastic
Tensile strength	32 lbs. per sq. in.
Air shrinkage	7.5%
Cone 4—	
Fire shrinkage	5.9%
Color	cream
Cone 6—	
Fire shrinkage	7.4%
Color	cream
Hardness	steel hard
Cone 13—	
Fire shrinkage	7.7%
Color	buff
Fusing point	cone 33

The following is a chemical analysis of this clay:

Moisture at 100° C.	1.03
Loss on ignition, water	11.03
Silica, SiO_2	52.17
Alumina, Al_2O_3	31.32
Ferric oxide, Fe_2O_3	1.85
Manganous oxide, MnO	trace
Lime, CaO	trace
Magnesia, MgO	.14
Sodium oxide, Na_2O	.24
Potassium oxide, K_2O	.24
Titanium dioxide, TiO_2	1.58
Sulphur, S	.01
Total	99.61

Rational analysis:

Quartz	15.55	Sand	17.11
Feldspar	1.56		
Clay substance			82.89
Total			100.00

It is hardly to be expected that the clay will be suitable for the higher grades of clay wares or as a paper filler, its dark color when burned, and high percentage of sand are objectionable. With its good plasticity, high refractoriness and fair bonding power, it should be suitable for a great variety of clay products, as fire brick, terra cotta, stoneware, etc.

It will be noted that its air shrinkage is greater and its fire shrinkage less than in the kaolins. Also very little or no cracking took place during the burning.

East of Fort Valley, and in the vicinity of Powersville, a number of deposits of clay were observed in the red sands. It is probable that most of these clays will be found to have similar properties to the clay just described, and the tests given above, will apply in a general way to them.

BYRON.—In a cut of the Central of Georgia Railroad, 2 miles north of Byron, an excellent exposure of Cretaceous sands and clays may be seen. The cut is 10 to 40 feet deep and a half mile long. On the whole the occurrence of the clay is quite similar to that at Griswoldville in Jones county. Two clay beds occur which vary in thickness from 0 to 10 feet, and are overlain by 20 to 30 feet of loose sand. The beds are lens-shaped, and one bed is seen to thin out entirely and to be replaced by sand. The beds suffered erosion prior to the deposition of the overlying sand, and at one point a clay bed has been entirely cut through and removed, and the space filled by the overlying red sand. The following geological section was made about midway in the cut, and is of the strata on the east side of the cut:

		Feet
1	Red, crossbedded sand, containing some thin layers, overburden	20
2	Blue, plastic, micaceous clay	10
3	Gray, crossbedded, clayey sand	10
4	Hard, white, sandy clay	4+

Bed No. 4 dips beneath the level of the cut, and its full thickness is not seen. Clay bed No. 2 is darker in color than the lower bed, and has occasionally thin sand partings. The sand, No. 3, may increase in thickness to 20 feet. The quantity of clay as far as the writer knows has not been determined by prospecting, but judging from the exposures in the cut, and assuming that the beds have considerable lateral extent east and west of the cut, the quantity will be sufficient for any commercial purposes for which the clays are adapted. Since the property is so accessible to transportation, this place should be a good locality for clay mining.

Samples were selected by the writer from beds No. 2 and No. 4, and tested in the laboratory of the Survey.

Physical Tests on Byron Clay, Bed No. 2

This is a bluish or drab colored clay, when moist, becoming white or almost white when dry; it is soft and friable. When mixed with 40 per cent. of water, it is very plastic, a plasticity perhaps best described by the term *sticky,* and can be moulded into intricate shapes without showing fractures.

It is extremely fine grained, 98 per cent. of the crude clay passing a 200 mesh sieve, and contains a comparatively small per cent. of sandy impurities which consist chiefly of glistening or silvery scales of muscovite mica. The residue retained on the 200 mesh sieve, was examined under the microscope and found to consist almost entirely of muscovite mica, a few grains of quartz, and only a very small percentage of clay. Its slaking properties are good. The average tensile strength was low; the maximum was 20 pounds out of eight briquettes tested.

Burning Tests

Cone	*Fire-Shrinkage.*	*Color*	*Condition*
1	7.3%	dull white	soft
4	7.5%	dull white	steel hard
8	12.1%	cream color	slight checking
11	12.4%	cream color	slight checking

The clay was burned in a Deville furnace to cone 30, without being fused, and its fusing point will doubtless be found to lie above cone 33, 3,254°F.

It will be observed that the clay has a higher fire shrinkage at cones 1 and 4 than most of the soft kaolins tested, and it seems to burn to a denser body at lower temperatures.

Physical Tests on Clay from bed No. 4, Byron

This clay is white and lighter in color than the above, and contains a large percentage of sandy impurities, though parts of the bed will be found very free from sand. It has good plasticity and slaking properties, though slightly indurated. Its tensile strength was 20 pounds per square inch; the average air shrinkage was 5.4 per cent. In the sieve test, 70 per cent. passed a 150 mesh sieve. The sand retained on the sieve consisted principally of quartz and muscovite mica and some ferruginous minerals.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
5	3%	dull white	soft
8	7.2%	cream	dense body
13	7.7%	dark cream	dense body

The low fire shrinkage is due to the high percentage of sand, as otherwise the clay is quite pure and a high shrinkage would be expected. This clay burned without checking or cracking, which may also be accounted for by the sand. The dark color to which it burns is due evidently to ferruginous sandy particles, as the washed product and some small pieces in the natural state burn white.

The clay is highly refractory, and should be suitable for fire clay products.

Bonaire.—Bonaire is located on the Georgia Southern and Florida Railroad in the eastern part of Houston county, and is about 23 miles south of Macon. A deposit of white clay lying about 4 miles southeast of this place, on the property of Chas. Thompson, has attracted some attention on account of the conspicuousness of the outcrop. The clay is exposed at the base of a steep bluff, bordering the Ocmulgee River swamp, and the bed is laid bare by the water flowing from a rather bold spring above it. The following is a vertical section of the bluff:

		Feet
1	Loose, brown sand	6
2	Thin, drab clay layer	3
3	Red sand	4
4	White stained clay	4
5	White sand	15
6	White, stained clay	10+

The clay bed, No. 6, is semi-hard, bluish-white, with purplish and yellow stains of iron oxide, which seem to permeate the mass of the clay and are not merely surface stains. Doubtless a greater thickness than is shown above, will be found; the lateral extent of the bed has not been determined, but no natural exposures of it were seen either to the north or to the south of the outcrop at the spring. It is believed the strata here belong to the Upper Cretaceous sands, a characteristic of which is lens-shaped beds of clay, rather restricted in area. The clay is at present too far removed from transportation lines, to be of much commercial value, even were it proved to be of exceptional quality.

The following is a chemical analysis of a sample selected by the writer; it is representative only of that part of the bed, which is exposed naturally:

Moisture at 100° C.	0.49
Loss on ignition, water	13.59
Silica, SiO_2	45.42
Alumina, Al_2O_3	38.10
Ferric oxide, Fe_2O_3	1.41
Lime, CaO	none
Magnesia, MgO	trace
Soda, Na_2O	trace
Potash, K_2O	0.10
Titanium dioxide, TiO_2	1.10
Total	100.21

Rational analysis:

Quartz	1.85	Sand	2.20
Feldspar	.35		
Clay substance			97.80
Total			100.00

The analysis shows a higher percentage of iron oxide than is found in the pure kaolins in Twiggs county and other localities, but the clay is otherwise very similar in chemical composition. The clay is a cream color when dry and pulverized; and has good plasticity; its air shrinkage was 6.5 per cent. tensile strength very low not exceeding 12 pounds per square inch; slaking properties good.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	9.6%	dull white to cream
10	18.0%	bluish-gray

Judging from the above tests, it is a high grade fire clay but not a kaolin, suitable for white ware pottery. The fire shrinkage is excessive; it checks or cracks badly in burning. With the disadvantage of location overcome, it should be valuable for fire clay, terra cotta and stoneware mixtures and other uses to which refractory clays are put.

Throughout Houston county there are perhaps many deposits, not mentioned in this report, which it was not possible nor necessary to examine, since facts concerning them may be largely inferred from the descriptions given of the above localities.

CRAWFORD COUNTY

Crawford is one of the Fall Line counties, and the southern half of the county is underlain by Cretaceous strata. There are a number of localities in this county very interesting from a geological view-point, and some of its white clay deposits may be of future economic importance. There is a small pottery industry in the county, the ware made, being common earthernware, consisting of jugs, jars, crocks, churns, etc., which are nearly all sold locally.

Rich Hill Locality.—Rich Hill is 5 miles southeast of Roberta, the nearest railroad station, and is the most interesting locality in the county. The hill is about 150 feet high, and is deeply trenched by gullies, both on the north and south sides, which have laid bare the strata composing the hill. At the base of the hill are exposed the white, crossbedded, kaolinic sands of the Tuscaloosa, and above are beds of "rotten" and compact limestone, and impure clay-shale, while the hill is capped by a brilliant red, case-hardened sand. The following geological section made along the south slope of the hill, may be of some economic value in showing the position of the white clay, and the nature of the overlying beds.

		Feet
1	Brilliant red sand, covering the upper slope	30
2	Purplish and yellow sand, with very thin clay partings	12
3	Greenish, clay-shale, with thin, lignitic layers	4
4	Sticky, calcareous clay	½
5	Drab, clay-shale, jointed, containing sand partings	6
6	Fossiliferous, calcareous layer, nodular	1
7	Drab, soft, clay-shale, full of fossils	12
8	Limestone	20
9	Brown and yellow, fine sand	12
10	White, micaceous clay; maximum	10
11	White, crossbedded, clayey sand	10
12	White, micaceous clay	3
13	Coarse, white sand	10+

The clay layers, 10 and 12, show variations in thickness and texture, and in places show great purity.

In a gully on the north slope of the hill, a thickness of 10 to 12 feet of white clay of fair quality was observed; but it is seen to grade into a micaceous and very sandy clay. The white clay at Rich Hill is both hard and soft, and doubtless greater thicknesses than are here mentioned may be found. The following are some tests made upon a soft, white clay from this locality. Tests on samples from other beds or localities in the hill, may show different results.

Physical Tests on a White Clay from Rich Hill

The clay is soft, and white to cream colored; it shows a large percentage of muscovite mica and some quartz sand, together with minute black specks of some ferruginous mineral or minerals. Its slaking properties and plasticity were good; tensile strength low, 16 pounds per square inch. Its air shrinkage was 8 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
3	2.2%	white with black specks
7	5.8%	" " " "

The clay was completely fused at cone 36.

From information, based upon field and laboratory work, the white clay at Rich Hill is a high grade fire clay, and some of it gives promise of being suitable for the purposes of kaolins, but its inaccessibility is a serious disadvantage, and mining would be difficult on account of the great thickness and nature of the overburden.

Pottery Industry.—In the eastern part of the county, a number of white clay beds were observed, but the beds are thin and the clay usually in small quantity. At Williams Mill, 6 miles east of Roberta, 4 feet of white, sandy clay is seen. This clay is used by the small jug factories in this vicinity. The jug industry in this county is unique. The potteries or "jug factories" as they are called, are all located in the interior of the county, removed from transportation, and the industry is carried on in a primitive way by farmers who are still using the methods their fathers used 50 years ago. The ware, which consists chiefly of jugs, is made from a mixture of "chalk" or white clay and swamp mud, which may be obtained along any of the streams in this part of the county. The glaze is a mixture of lime and swamp mud, or lime, swamp mud and stream sand, and may be colored by a ground, siliceous limonite which occurs abundantly in this part of the county.

In some instances, the potter burns his own lime, using the soft limestone at Rich Hill for this purpose. The ware is burned in low, dome shaped or rectangular ovens, which have a capacity of 300 to 500 gallons. The jugs are mostly hauled to Macon in wagons, a distance of 20 to 25 miles, and are used in the whiskey trade.

In 1906 there were 12 potteries in the eastern part of the county, and their total output was about 160,000 gallons. The figures are only an estimate as the potters keep no records and trust entirely to memory.

ZENITH.—Zenith is located on the Southern Railroad, 7 miles northwest of Fort Valley, a conspicuous deposit of white clay occurs here in a gully on the property of Phil Ogiltree. From the bottom of the gully to the cultivated field above, the vertical distance is about 90 feet. The clay shows considerable variation in texture and quality. At the bottom of the gully there is 14 feet of white clay considerably stained by iron oxide; above this there seems to be an interval of sand, about 10 feet, and then a clay bed 20 feet in thickness, which is in turn overlain by 30 feet of ferruginous sand.

The lower part of the 20 foot bed is sandy, and very variable in character, and the best clay observed, was the upper 8 feet, exposed at the head of the gully. The overburden, consisting for the most part of unconsolidated red sand, amounts to about 30 feet.

The quality of the clay concealed by the overlying red sand, is not known, and information concerning the deposit is based upon the natural exposures alone.

Physical Tests on Ogiltree Clay, Zenith

The clay tested, was a sample from the upper part of the twenty foot bed.

Color	white to cream
Texture	fine grained
Hardness	soft, friable
Slaking	good
Plasticity	very good
Tensile strength	very low
Air shrinkage	4.1%
Cone 4—	
Fire shrinkage	4.5%
Color	pure white
Cone 9—	
Fire shrinkage	10.8%
Color	light cream

The following is a chemical analysis:

Moisture at 100° C.	.486
Loss on ignition, water	12.239
Silica, SiO_2	49.020
Alumina, Al_2O_3	35.603
Iron oxide, Fe_2O_3	.845
Manganous oxide, MnO	trace
Lime, CaO	.040
Magnesia, MgO	trace
Soda, Na_2O	.032
Potash, K_2O	.065
Titanium dioxide, TiO_2	1.352
Total	99.682

Rational analysis:

Feldspar	1.064	Sand	10.952
Quartz	9.888		
Clay substance			89.048
Total			100.000

Except for the high percentage of quartz sand, the clay is quite pure; the common fluxing impurities amount to only .982 per cent., and it should be in point of refractoriness, a No. 1 fire clay. If washed, it would give some promise of being both a paper and pottery kaolin.

In the railroad cut, a short distance north of Zenith station, a clay bed is exposed for a distance of 150 yards along the cut. There is much staining from iron oxide at the surface; the bed has a maximum exposed thickness of 12 feet; and is probably only a fire clay. There is a bed of black and drab shaly clay overlying this stained clay, which contains bits of lignitized leaves and wood and some few small pieces of fossil resin or amber.

EVERETT.—An outcrop of clay, occurring in a cut of the Central of Georgia Railroad, at Everett, 5 miles west of Fort Valley, was examined, and the clay here is the same geological position as that at Zenith. The bed is partly concealed by drift from the overlying sand, so that only 6 or 8 feet of it is exposed; it is drab or even a faint lavender in color; this color may be only a surface phenomenon and the clay may be purer where not exposed. It is free from any coarse sand, and jointed. It is overlain by unconsolidated red sand which contains some white clay intermixed with it. No prospecting has been done, and no information can be given as to the extent and thickness of the deposit. The clay has good plasticity; very low tensile strength; its air shrinkage was 5.3 per cent. At cone 4, it burned to a dull cream color, gave a fire shrinkage of 6.9 per cent. and showed no checking; at cone 8 the fire shrinkage was 8.3 per cent., and the color slightly darker than at cone 4. The clay tested, is not suitable for white ware pottery, nor for use as a paper filler. It is possible that purer clay than that tested, may be found.

MACON COUNTY

In the northern half of Macon county, there is a belt of Upper Cretaceous sand in which pockets and beds of white clays have been found. At no place where these have been examined, do they approach in purity and thickness the clay beds of the Tuscaloosa east of the Ocmulgee River. Most of them will probably be found highly refractory, but not suitable for the higher grades of clay wares.

A sample of fire clay was taken from a gully or wash on the Frederick place, 2 miles northwest of Marshallville. The bed showed a thickness of 6 to 8 feet, and was stained by iron oxide and contained a small percentage of sandy impurities. It is overlain and underlain by ferruginous and clayey sands, and is probably only a lens or pocket since it gives evidence of thinning out in the gully where it is exposed. The clay showed fair plasticity; its tensile strength was 20 pounds per square inch; air shrinkage 6.2 per cent. It burned to a cream color at cone 4, and showed a fire shrinkage of 6.7 per cent.

At cone 8, a dull cream or drab color, steel hard, no cracking and a fire shrinkage of 8 per cent. The dark color to which it burns, will preclude its use for white ware pottery.

Some white stained clay, was noted on the west side of Flint River, north of Oglethorpe. A clay bed is exposed in the cut of the Atlanta, Birmingham and Atlantic Railroad, near Maverick, and a bed may be seen in the public road about ¾ mile west of Maverick, adjoining the property of J. M. Childs. The bed at the latter locality, is 8 feet thick; it is white with purplish and red stains, which seem to penetrate the mass of the clay, and in places is quite sandy. The extent of the bed is not known, but it will probably be of small area. It is probably a fire clay, but is not pure enough to be a kaolin, and could not compete with the purer and more extensive deposits at other localities. A sample tested in the laboratory showed an air shrinkage of 8 per cent., its tensile strength was 15 pounds per square inch. At cone 4, it burned to a dull white or faint cream color, and showed a fire shrinkage of 8.2 per cent., and was steel hard; at cone 10, it burned to a cream color with a shrinkage of 10 per cent.

There are a large number of exposures of clays in the red sands west and northwest of this locality; some of the exposures noted, showed a thickness of 15 feet or more, but all were splotched with iron oxide stains. There is very little local demand for clay products in this part of the State, and any white clays to be of value at present, must show some exceptional qualities.

TAYLOR COUNTY

Sands of both the Upper and Lower Cretaceous occur in this county and are clay bearing. The sands of the Lower

Cretaceous are not easily distinguished from those of the Upper Cretaceous, and the white clays of both are similar in occurrence, but those in the vicinity of Butler, in the Tuscaloosa, are purer and more extensive than elsewhere in the county.

North of Butler the sand is noticeably coarser and more pebbly than south; there are beds of coarse, granular quartz pebbles and occasionally some feldspar pebbles; and at one point, a hard clay-arkose breccia, similar to that noted at Grovetown and Hephzibah, was found. The sand in the southern part of the county, contains noticeably more iron and the clay beds are thinner and less pure. A characteristic feature is thin crusts or layers, a few inches thick, and large hollow nodules of siliceous limonite; the latter are so abundant in some localities that they may be of some value in the future as a source of iron.

Butler

Some clay mining has been carried on by the Butler Clay Company, at a point 2½ miles west of Butler, but operations were suspended in 1905. The clay deposit is about 1½ miles south from the nearest point on the Central of Georgia Railroad, but can be easily reached by a spur track. The bed is typical of the deposits in the western belt of the Tuscaloosa, and at the time of my visit to the property, the pit was sufficiently clear of debris for a fairly good exposure of the clay bed to be seen.

The following section could be seen in the pit:

		Feet
1	Red, crossbedded sand	4
2	Drab kaolin, fair quality	8
3	Very sandy clay	2
4	Jointed kaolin, good quality	8
5	White quartz sand	1+

The clay bed shows no continuity of deposition; it may terminate abruptly and grade into or be replaced by sand,

SHALE PIT OF THE GEORGIA VITRIFIED BRICK AND CLAY COMPANY, BELAIR, RICHMOND COUNTY, GEORGIA.

to again appear as pure clay. The lower part of the bed in the pit is jointed, a drab or gray in color, free from staining and contains only a small percentage of sand.

The following is a section of a well sunk for water a few yards south of the pit:

		Feet
1	Sandy clay	12
2	Sand with small amount of clay	15
3	White clay	4
4	Quartz and mica sand	4
	Total	35

The white sand underlying the clay bed, outcrops in the valley south of the pit, and does not contain any clay beds of importance. The owner of the property reports that he prospected 25 acres east of the pit, and found clay underlying the whole area, the overburden varying from nothing to 16 feet. The indications for a large quantity of clay are good, though doubtless lack of uniformity, both in texture and thickness, would have to be contended with in mining. One very great advantage, however, is the small amount of overburden.

The clay which was mined several years ago, was shipped to northern markets as a filler for wall paper, and some was used for sizing cotton cloth in the cotton mills at Columbus Georgia.

The clay was cleansed in a Raymond pulverizer and air separator, with a capacity of about four tons per day. An examination of some of the clay prepared by this process showed that the process was efficient only in removing the coarse quartz particles; the amount of iron oxide in the clay was not lessened and but little difference was affected in the chemical composition or purity. In handling a clay of the nature of the Butler deposit, it is not believed that this process is as practicable as clay washing.

Samples collected by the writer, were tested in the laboratory with the following results. The physical tests were made upon a sample of the purest clay.

Physical Tests of Butler Kaolin

Color, when dry, almost white or a faint cream; it is very free from sand, the chief impurities being muscovite mica and some coarse quartz sand. It has excellent plasticity, and requires 44 per cent. of water to develop the maximum. Its tensile strength is very low, not exceeding 12 pounds per square inch. It is very fine grained, in the sieve test 95 per cent, passed a 200 mesh sieve. Its air shrinkage is 4.7 per cent. and slaking properties excellent.

Burning Tests

Cone	*Fire Shrinkage*	*Color*
3	4.7%	pure white
5	7.5%	white
9	11.8%	white
15	13.3%	white, black specks

The fusing point of the clay lies above cone 33, 3,254°F.

The burned color is good, but as in the case of nearly all of the Fall Line kaolins tested, unless very carefully burned, it cracks badly. The black specks noted are evidently due to the fusing of some easily fusible mineral which exists in the clay as a sandy impurity, and, to some extent, at least, would be eliminated if the clay were washed. The clay has a good "sticky" plasticity, and remains in suspension readily when slaked in water, and is a first rate clay for paper filling. In point of refractoriness it is a No. 1 fire clay.

The following is a chemical analysis of a sample of the Butler kaolin:

Moisture at 100° C	0.628
Loss on ignition, water	12.640
Silica, SiO_2	46.755
Alumina, Al_2O_3	36.594
Iron oxide, Fe_2O_3	1.045
Lime, CaO	.080
Magnesia, MgO	.102
Manganous oxide, MnO	trace
Soda, Na_2O	.145
Potash, K_2O	.288
Titanium dioxide, TiO_2	1.472
Total	99.749

Rational analysis:

Feldspar	1.498	Sand	6.639
Quartz	5.141		
Clay substance			93.361
Total			100.000

The above analysis is of a sample of the purest clay, but it had received no mechanical preparation. Although, as shown by the above analysis, the amount of iron, Fe_2O_3, is above one per cent., the clay burns whiter than many other kaolins tested, in which the iron content was much smaller.

In a hillside about one-fourth mile west of the Butler Clay Company's plant, there is a natural exposure, showing 15 feet or more of clay. The bed at this point is in the same geological position, and lies at about the same level as the bed at Butler's, and the clay will probably be found similar in its properties.

North of Butler.—Clay is found in the ravines a short distance north and west of the station at Butler. It occurs in considerable quantity, but is streaked and mottled by iron oxide, but will no doubt be found highly refractory.

An attempt was made to mine a white clay about 4 miles northeast of Butler by Messrs. Anthony and Gooding. The clay bed at the time of my visit, showed a thickness of 10 feet, and was somewhat sandy and stained by iron oxide. It is overlain by 15 feet of coarse pebbly sand. The property is rather inaccessible and the quality of the clay probably did not justify its exploitation.

Forty-six Milepost.—A deposit of clay was noted in a cut of the Central of Georgia Railroad near the 46 milepost. The clay is iron stained at the surface and is not a kaolin, but may be of some value, as a fire clay, on account of its accessibility.

TALBOT COUNTY

Only a narrow strip, 6 or 7 miles in width, in the southern part of this county, is underlain by sediments of the Coastal Plain. The clays of the Cretaceous observed, were inferior in quality.

The tests on a sample from near Junction City, will indicate the character of the thin clay beds occurring in this vicinity. The clay is white, or almost white when dry, and contains a very high percentage of sandy impurities, chiefly mica and quartz. Its plasticity is poor when compared with that of the purer clays of other localities; air shrinkage 3.7 per cent.; tensile strength very low, not exceeding 10 pounds per square inch. Burned at cone 5, it showed only 1 per cent. fire shrinkage; burned to a cream color, and was soft and friable. At cone 13, it showed only 1.4 per cent. fire shrinkage, due evidently to the very high percentage of sand, and burned to a beautiful speckled buff. It was fused at cone 30, 3,146° F. The clay is not a kaolin, and can hardly be classed as a No. 1 fire clay.

The Tuscaloosa formation in the vicinity of Geneva, differs in appearance from the formation as exposed elsewhere in the State. It is here composed largely of indurated material, and consists of alternating layers of indurated clay and sandstone. The clay layers are thin, dark colored, jointed and often sandy, and are at present of no commercial value, though they may be found refractory.

The following section of a hill, about 2 miles southeast of Geneva, will indicate the character of the strata:

		Feet
1	Clay	3
2	Soft sandstone	15
3	Jointed, purplish clay, indurated	6
4	Soft, yellow sandstone	20
5	Purplish, hard-jointed clay, with large quartz grains	5
6	Soft, yellow, cross-bedded sandstone	20

To the southward, the section is overlain by a loose, brown or yellow sand, belonging to Upper Cretaceous strata (Eutaw). North and west of Geneva, near the contact with the crystalline rock, the material composing the Cretaceous is coarse and the clay is brilliantly colored by iron.

MARION COUNTY

The northern part of this county is underlain by a great thickness of red and brown sands and sandy clay-marls, belonging to the Eutaw and Ripley formations. There is a great abundance of clay, but it does not approach in purity the clays of the eastern belt of the Cretaceous. The white or light colored clays occur in pockets or in thin non-persistent layers in the sands, and may be dark in color from organic matter, and frequently contain thin layers of limonite. In the Ripley formation, there are black and gray sandy, clay-marls, attaining great thickness. The northern part of the county is thinly settled, and without railroad transportation, and there has been no stimulus for the development of its clay resources. The prospects, however, for high-grade clays or kaolins in large quantity, are not very favorable.

MUSCOGEE COUNTY

The clays of the Cretaceous in this county, are relatively unimportant; the clay industry of Columbus, the largest city of western Georgia, is confined entirely to the manufacture of common building brick, and the clays of the alluvium of the second terrace along the Chattahoochee River are used, and will be described in another part of this report.

The relations of the Tuscaloosa formation to other geological formations, may be seen in the gullies on the Alabama side of the Chattahoochee, opposite Columbus.

The following section is exposed:

		Feet
1	Brown-yellow loam	12
2	Vari-colored, jointed, plastic clay, variable in thickness	12
3	White micaceous sand	4
4	Coarse gravel	0 to 2
5	Disintegrated gneiss	15

The brown loam at the top is a Pleistocene alluvium; the Tuscaloosa clay is plastic, sandy, mottled, and may be bluish or greenish in color, and grades into disintegrated gneiss.

The Tuscaloosa in the vicinity of Columbus, consists of coarse, cross-bedded sand and gravel, with beds of plastic, colored clays, the whole resting upon arkose or disintegrated gneiss, and capped by red pebbly sand. No white clays of high refractoriness or purity are known. Southeast of Columbus, red, and black or drab, lignitic clays and clay-marls of the Eutaw formation, occur.

There is a great thickness of colored sands in the eastern part of the county, but no very pure white clays are known to occur, though possibly fire clays of fair quality could be found.

CHATTAHOOCHEE COUNTY

This county, as shown by the map accompanying this report, lies within the belt mapped as Cretaceous; but as far as is known, it contains no fire clays or kaolins of any importance. There are great thicknesses of drab or dark colored laminated clays and red sandy clays, which would be suitable only for common building brick, or other low grade clay products.

STEWART COUNTY

There is a great thickness of red and white sands and clay-marls in Stewart county, belonging to the Upper Cretaceous formation. There are white clay layers in the sands, but these where examined, have been found sandy, or mottled with iron oxide, and in no place approach a high-grade kaolin in purity. Tests upon small selected samples may show up high-grade clays, but such are very frequently misleading, since the sample does not represent a commercial quantity.

Some of the deposits may have some value in the future as fire clays. The white clay layers are as much as ten feet in thickness, but are usually much less.

A small sample from near Lumpkin, showed a good plasticity, air shrinkage 6.5 per cent., and burned to a cream color; showed a low fire shrinkage, without checking. Its fusing point was above cone 30.

A good exposure of light-colored, very sandy clay, probably representing the top of the Cretaceous strata, occurs in the railroad cut east of the depot at Lumpkin.

CHAPTER VI

PROPERTIES AND USES OF THE FALL LINE OR CRETACEOUS WHITE CLAYS

The belt of the Cretaceous strata, between Macon and Augusta, in which white clays occur, is approximately 110 miles in length and from 3 to 15 miles in width. Throughout this area white clay beds, kaolins and fire clays, 6 to 35 feet in thickness occur; these do not occur as individual continuous beds for the whole distance, but as separate, lens-shaped beds of variable extent and thickness. The distance between Macon and Columbus is approximately 85 miles. In this western belt the Cretaceous sediments are 20 to 25 miles in width with a maximum of 50 miles on the Chattahoochee River. The clays of this belt are not as a whole as pure nor as extensive as those east of Macon, but valuable clays exist and await development. The white clays of the Fall Line region exist in almost inexhaustible quantities, are easily mined and are in a large measure accessible to railway lines.

CHEMICAL AND MINERALOGICAL COMPOSITION.

The chemical purity of the clay is often most remarkable, especially when the origin of the clays is considered, and the belt of clays extending from the vicinity of Macon to Augusta is probably the most extensive belt of pure clays in the United States. The purest of the clays approach in composition kaolinite or theoretically pure clay, one sample analyzed by the Geological Department showed 99.16 per cent. clay substance; from this purity, the clays range to those containing very high percentages of sand and other impurities, though all are more or less white in color. The chemical analyses given in the preceding chapter are not in any way misleading, and for the most part represent commercial quantities, and when the analysis is from a selected sample or happens to be less pure than the deposit as a whole, it is so mentioned in the report.

SILICA.—The clays range in silica, as shown by 36 analyses from widely separated localities, from 40.28 to 60.44 per cent.; the amount of free silica or sand in the above analyses ranged from 0 to 20.66 per cent. The amount of combined silica approaches closely that in kaolinite. The ratio of silica to alumina in kaolinite is 1.16:1.00; the ratio in 15 of the purest clays of the Fall Line belt was from 1.10:1.00 to 1.24:1.00, and two showed 1.16:1.00. The highest silica-alumina ratio, 1.24:-1.00 was in a hard fire clay from the property of J. R. Van-Buren, Griswoldville; the explanation of this is probably that the clay contains a large percentage of soluble hydrous silica which is not in combinaion, but is given so in the analysis, and the presence of a small amount of other silicates, as feldspar and mica. The alumina in 36 selected analyses ranged from 25.75 per cent. to 40.42 per cent., while the average is above 35 per cent. The clays will be found generally high in alumina, and where a low percentage is shown by the analysis, it is due to a large amount of sand. Some clay associated with bauxite, which has been recently discovered in Wilkinson county, will probably show an excess of alumina over silica due to the presence of bauxite.

IRON OXIDE.—The amount of iron oxide is 35 analyses ranged from 0.51 to 2.11 per cent., and the average of the 35 was 1.01 per cent.; 16 showed less than 1.00 per cent., and 19 above 1.00 per cent. None of the clays from which the analyses were made had been washed, and it is certain that the amount of iron could be reduced to some extent by washing. The iron exists mainly in the form of the oxides limonite and hematite, and the amount derived from iron bearing silicates is very small. The iron is generally in a very finely divided state and is uniformly distributed, though often existing as spots and as minute "pimples" or concretions. In making burning tests on the clays it was generally observed that these clays which contained above 1.00 per cent. of iron oxide, gave a cream tint.

LIME.—Lime exists in inappreciable quantity. Out of 36 analyses, 26 contained no lime or only a trace, and the average in the 36 was only 0.05 per cent. The highest percentage shown was 0.40 per cent. Lime when present is derived from silicates, feldspar, hornblende and pyroxene. No lime carbonate nor sulphate has been observed.

MAGNESIA.—Magnesia is also in very small amount, but is slightly in excess of lime, due no doubt to the abundance of mica in the clays. The range of magnesia was from 0 to 0.82 per cent., with an average in 36 analyses of .08 per cent.

SODA.—The soda content is small, the range in the analyses available being from 0 to .83 per cent., with an average of 0.10 per cent. It is more common than lime and less common than magnesia. Its source is in the main from feldspars, but may be in part derived from micas and other silicates.

POTASH.—Potash slightly exceeds soda in amount and is more universally present, though the amount is never great. The range in 36 analyses was 0 to .71 per cent., with an average of 0.17 per cent. Its source is from the micas and feldspar.

TITANIUM.—Titanium dioxide is universally present. In 33 clays in which tests for it were made, the range was from 1.14 per cent. to 2.26 per cent., and the average 1.44 per cent. It is more common and in greater amount than lime, magnesia, soda and potash, and in the clays tested is in greater quantity than iron oxide. In regard to its source, it is possible for it to be derived from rutile, ilmenite, titanite and perovskite.

If derived from a separate mineral at all, its source is most likely rutile, and if derived from rutile, the mineral is in an extremely fine state of division, as fine in fact as the finest clay particles, since analyses of very fine clay, obtained by floating, show higher amounts of titanium dioxide than those containing coarse sand. This fact justifies the suggestion that the titanium is in part at least in chemical combination with the clay substance.

Ground rutile mixed with kaolin is known to produce a yellow coloration and at very high temperatures to give a bluish tint, but as far as the writer could observe in testing the Fall Line clays there was no color traceable to titanium, and the refractoriness of the clays is doubtfully lowered by it.

WATER.—The amount of combined water is high, usually 12 to 14 per cent., and it is only in the very sandy clays that it is less than this.

OTHER CONSTITUENTS.—Rarely an analysis shows a trace of sulphur and phosphorus pentoxide due doubtless to an accidental grain of pyrite and apatite. A trace of manganese oxide is also sometimes shown, which is not surprising, since it is observed in localities as a thin coating along joint planes. Carbonaceous matter is never present.

MICROSCOPIC EXAMINATION.—The clays were examined under the microscope, both in thin sections and as a powder unmounted. The clay substance appears, in the soft clays, in milky and translucent aggregates. No kaolinite crystals were detected. Quartz is present, usually as small angular and subangular particles, often coated with iron oxide. Angular, glassy, dark-colored grains are frequently present and are probably smoky quartz.

In the flint clays some opaline silica was present and is doubtless the cementing agent in such clays.

Muscovite mica is very abundant and occurs in very minute flakes up to silvery scales easily recognizable without the aid of the microscope. Some feldspars could be seen, but the varieties could not be determined. Limonite and hematite occur as a coating over other minerals and in separate grains.

Magnetite is rarely present, and there are occasionally black grains which are questionably ilmenite. In one clay, a cube of pyrite was distinctly recognized, but no trace of pyrite was observed in any other clays. Careful search was made for rutile, but nothing that could be positively recognized as such was found.

Hornblende, pyroxene, garnet, biotite and other minerals common to igneous and metamorphic rocks in the Piedmont Plateau are found in the sands of the Cretaceous and are doubtless present also in the coarse sandy clays, but can not be identified with certainty in the finest and purest white clays.

The minerals in appreciable quantity are quartz, muscovite mica, feldspars, and iron oxide, mostly limonite or other hydrous oxides.

PHYSICAL PROPERTIES

The white clays are both soft and hard; the soft clays are unctuous or greasy to the touch and are sticky or glue-like when moist; there are some semi-hard or slightly granular clays and some which are very hard and break with a conchoidal or splintery fracture. The soft clays are highly plastic, and when worked up to their best plasticity can be moulded into almost any desired form, that is, they will show a great amount of deformation without breaking. Upon drying, however, the clays usually have only low strength; but there are some notable exceptions. The very hard clays are "mealy" or granular and show very little plasticity. The amount of water required to develop maximum plasticity is high, 30 to 45 per cent. of the dry weight of the clay.

TENSILE STRENGTH.—The dried strength ranges from 10 pounds to as high as 140 pounds per square inch. The very soft, flour-like clays and the very hard seem to show the lowest strength, while those intermediate show the highest. Those clays possessing good strength also have high bonding power. A clay from Dry Branch gave a strength when mixed with 50 per cent. of non-plastic material, of 112 pounds per square inch, while the original strength of the clay was 140 pounds per square inch. The non-plastic material used was sand, which was run through a 40 mesh sieve, but none of it would pass through an 80 mesh seive. The clays when burned alone show a low strength on account of numerous cracks developing in burning.

SHRINKAGE.—The drying shrinkage of the clays is generally low, from 3.5 to 6 per cent. The fire shrinkage is high. In the purest clays it varies from 4 to 9 per cent. at cone 4, and from 10 to 15 per cent. at cone 9. The shrinkage seems to increase gradually and uniformly from about cone 03 to cone 9; from cone 9 to cones 12, 13, 14 and 15, the increase in shrinkage is only slight, and sometimes there is none at all.

FUSIBILITY.—The purer clays are soft, even at cone 4, but are steel hard at cone 9. None of the clays tested, even the very sandy fire clays, showed vitrification at cone 15. The purest clays are not at all glassy at cone 30, and having fusing points from cones 33 to 36. None of the white Cretaceous clays have low vitrification points, and all, in which the natural sandy impurities do not exceed 20 per cent., have been found to be highly refractory clays.

COLOR IN BURNING.—The clays tested ranged in iron oxide content from 0.51 to 2.11 per cent., and gave colors ranging from white to cream, yellow and light buff. The purest clays likely to be of value for white ware products, were burned in a muffle; it was generally noted that those clays containing above one per cent. of iron oxide burned to a cream color, either faint or a decided cream, at cone 9. Burned in the open flame, at temperatures above cone 9, some of the purest clays assumed a gray or bluish-gray tint. Often minute black specks were observed in the bricklets of the white burning clays, due to the fusion of minute grains of iron oxide or to other easily fusible scattered mineral particles.

TEXTURE.—The pure clays are very fine grained. In making sieve tests, the air dried clay was first slaked in water, and then passed through sieves by playing a stream of water over it. It was found that as much as 95 per cent. and more of the pure clays would pass a 200 mesh sieve. Frequently, the quartz sand contained in the clays is coarse, and the amount of clay which will pass a 200 mesh sieve can usually be roughly approximated by the amount of sand it contains. The sieve tests are satisfactory only for those clays which are soft and slake readily into a fine powder. Some of the soft clays contain particles minute enough to remain in suspension in water almost indefinitely and in sufficient abundance to make the water milky or opalescent.

Specific Gravity.—The specific gravity of 10 kaolins and fire-clays tested by the pycnometer method ranged from 2.39 to 2.69.

COLOR IN THE RAW STATE.—The color of these clays range from white to cream, frequently stained light yellow and pink. Those that are cream colored or even light yellow when moist become almost white when dry. The color is due to the amount and distribution of iron oxide. The color in the raw state is of practical importance, since the clays are used for paper filling and coating. For such purposes, whiteness and uniformity of color is a requisite. The clays sometimes have pink or light red splotches in them. These are due to iron oxide and rarely to organic matter.

SLAKING.—The soft pure clays, when dry, possess the property of slaking in water to an eminent degree, and fall into a fine powder in a few minutes. The presence of moisture greatly retards the slaking properties. The hard clays disintegrate only slowly into rather coarse grains and the very hard, not at all or only with extreme slowness. The slow slaking of the hard clays is due to incipient cementation of the grains by opaline silica, and not to consolidation of the clays by pressure.

Uses

The white clays of the Fall Line or Lower Cretaceous of Georgia are now being used in he manufacture of white ware pottery, electrical porcelain, sanitary ware, etc., fire brick and other refractory products, and terra cotta. In the raw state, they are extensively used as a filler for wood pulp paper. The suitability of the clays for the above uses will be discussed and further uses suggested.

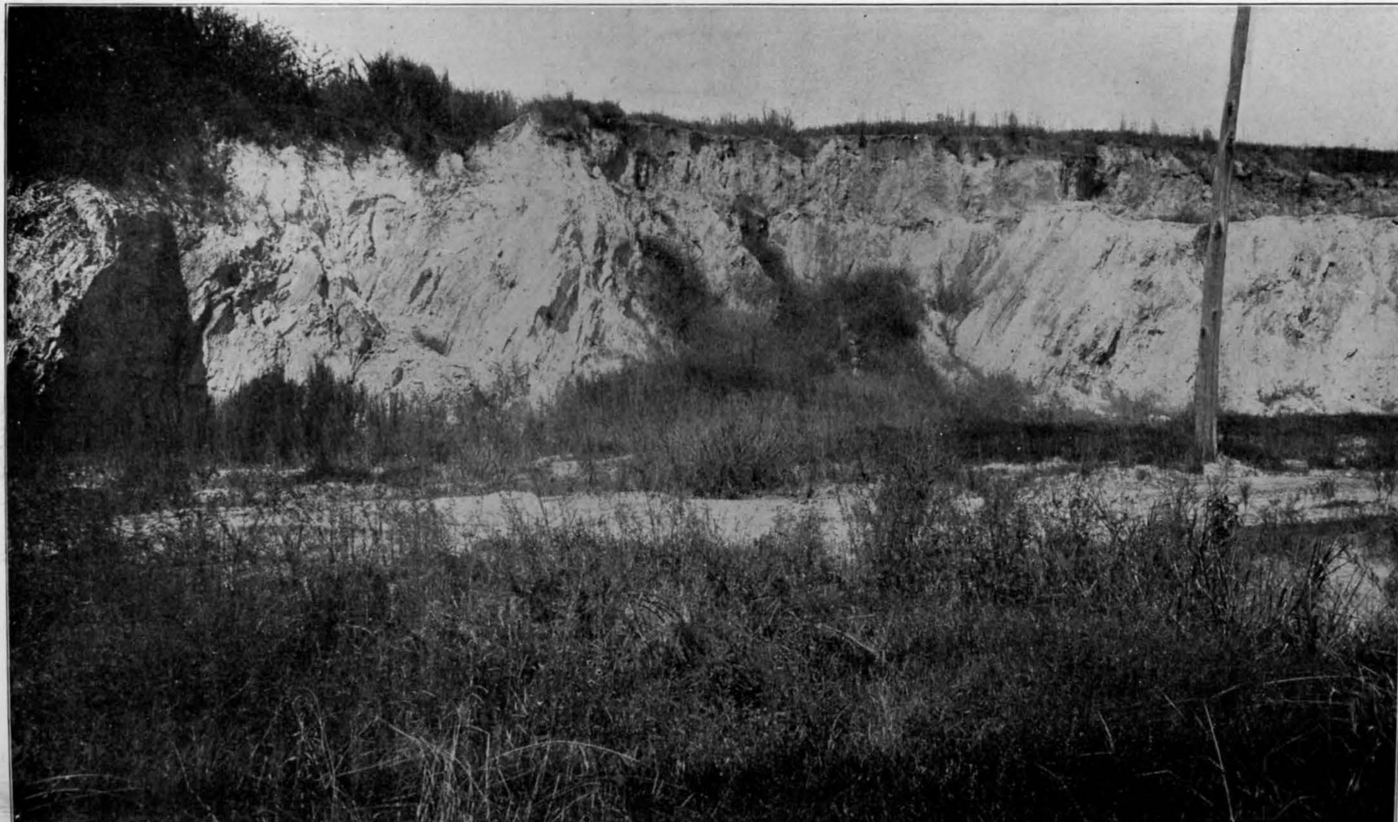
White Ware Pottery.—The purest clays from the mines at Dry Branch, have within the last few years been successfully used in the manufacture of white ware pottery, notwithstanding that their use for this purpose has been heretofore discouraged and that there is still skepticism among some of their value for this purpose. What is all the more remarkable is that the clays have been shipped from the mines in the crude state without washing. With the installation of washing plants greater uniformity and purity can be obtained. There are at present no white ware potteries in Georgia, and the clays have been shipped to Ohio, New Jersey and West Virginia potteries. The Georgia clays have excellent plasticity, frequently high strength and binding qualities which gives them some advantage over residual kaolins.

The amount of clay which is suitable for white ware pottery is small in comparison with the total amount of white clay in the Fall Line belt, and by no means, are all those clays which are white and comparatively free from grit adapted for pottery use, and many with less than one per cent. of iron oxide, may show too much color in burning and have other objectionable properties. The amount of clay, however, available either in the crude state or by washing is certainly sufficient to supply any demand, however great.

ELECTRICAL PORCELAIN SANITARY WARE, ETC.—The material exists for the manufacture of any refractory products now in use, with possibly only a few exceptions, such as glass pot clays and those for lining zinc muffles. In point of refractoriness the clays are equal to any in the United States of which tests have been published, nearly all of those tested by the writer having fusing points between cones 30 and 36. Both plastic and non-plastic clays occur which range in dried strength from 10 pounds to 150 pounds per square inch, while those of high strength have also high bonding power. Clays showing high strength and bonding power were found by the writer at Dry Branch, Griswoldville, McIntyre and Chalker. Coarse sand and sandy clays suitable for mixing in refractory wares occur in the same beds with the clays, and the bauxite of Wilkinson county, recently discovered by the writer, can be mixed with the plastic clays for the manufacture of very highly refractory and basic fire clay products.

ORNAMENTAL BUILDING BRICK.—The clays alone and in mixtures with red burning impure clays contiguous, could be used in the manufacture of white, cream-colored, yellow and buff dry press building brick, as well as enamelled and other ornamental brick. There is no reason why a factory manufacturing such products should not be successful in supplying Southern trade, which is now sufficiently great to justify such a venture.

PAPER FILLING.—The clays are used extensively for paper filling. The whiter such clays are, the better; they should possess good slaking properties, plasticity or spreading qualities, and freedom from grit. Greater uniformity in color and



Bluff, Opposite Augusta, Showing Contact Between the Cretaceous and Schists.

purity can be secured by washing the clays. They are only slightly inferior in whiteness to residual kaolins.

OTHER USES.—They can be used in the manufacture of sewer pipe, fire-proofing and paving brick, mixed with the alluvial clays of the large streams at the Fall Line, and the easily fusible schists of the adjacent Piedmont Plateau, such as at Belair in Richmond county. The minor uses of clays for which they might be suitable are: paint filler, alum, ultamårine manufacture and plaster. Some of the hard clays are quarried and sawed into blocks and used locally for building foundations and chimneys. On account of their purity, quantity, and cheapness of mining, they are a possible future source of the metal aluminum, and it only remains for a cheap process of separating the silica from the alumina to be invented.

THE ESTABLISHMENT OF FACTORIES IN GEORGIA

With an abundance of clays, the value of which in the manufacture of white ware pottery, sanitary ware, electrical porcelain, and other high-grade clay products, has been proven by their commercial use for such purposes in Northern factories, the question arises why not establish factories in Georgia for the manufacture of such products. As to the feasibility of establishing factories, which could be a commercial success, the following points are to be considered:

1 Suitability and availability of raw materials.

2 Labor.

3 Fuel.

4 Market, and transportation facilities.

The quality of the clays for white ware pottery, and other products has been proven. The quantity of such clay and its accessibility can not be questioned. White ware bodies are mixtures of kaolin, ball clay, flint and feldspar, and access to the latter materials must be considered. Flint or quartz of great purity occurs in veins throughout the Piedmont Region of Georgia, and as beds of quartzite or metamorphosed sandstone; a number of occurrences of feldspar have been noted in the State, and it is believed that veins of sufficient purity and thickness to be of commercial value may be found. The occurrence of flint and feldspar in Georgia will be discussed separately. Ball-clays are plastic clays of high strength and bonding power and which burn white or nearly white and to a dense body. No Georgia clays have been placed on the market as ball-clays, but some of the plastic kaolins of the Fall Line have the properties of a ball-clay, except that they have higher vitrification points. Such clays could largely replace ball-clays, without violently overturning the established methods of potters. It is also highly probable that other Georgia clays which will more nearly meet the requirements of ball-clays will be discovered in the future. Ball-clays in the United States are now obtained from Florida, Kentucky, Tennessee, Missouri, and New Jersey; English ball-clays are imported.

Clays for the manufacture of fire-brick, saggers, etc., occur in abundance.

Lack of skilled labor is one of the main arguments advanced against the establishment of potteries. Unquestionably skilled labor would have to be imported, but the labor problem is a problem which has to be met in the establishment of any new industry. It can only be a temporary disadvantage. To carry such argument to the extreme, would imply that no new industries requiring skilled labor could be established except in those localities where such skilled labor is most centered. The establishment of new industries in the South requiring skilled labor, which it was at first necessary to import and the successful operations of such industries, is the most forceful argument to advance against lack of labor.

Fuel is an expensive item in the manufacture of clay products. Coal for Georgia factories would have to be obtained largely from Alabama and Tennessee. The cost of coal would be somewhat greater than in Ohio and New Jersey potting centers, but a suitable quantity for ceramic firing could be obtained. Wood can not be considered as a reliable or permanent source of fuel.

Transportation and other manufacturing facilities would be good at Macon, Augusta, Columbus and Atlanta, and raw material within easy access. Taking all things into consideration, the writer believes that manufactories for white ware pottery and other high-grade clay products can be successfully operated in Georgia. Such factories would have material advantages in supplying Southern trade, and could be active competitors for western trade, and entrance into Northern and Eastern markets would take place as they became more firmly established.

Occurrence of Flint and Feldspar in Georgia

There are good prospects of both flint and feldspar, both used extensively in the manufacture of white ware pottery, tiling, electrical porcelain, etc., being found in the Piedmont region of Georgia. Heretofore there has been no incentive to prospect for either on account of no market in the South and excessive freight to Northen markets.

Vein quartz of great purity occurs throughout the Piedmont Plateau and the Blue Ridge. The most notable localities known to the writer are at, 1, Burwell, 8 miles west of Carrollton, Carroll county; 2, Kell Mica Mine, Rabun county; 3, Turner Mica mine, 5 miles north of Dallas, Paulding county. A granular quartzite, of loose texture, is located on the Payne property, 5 miles west of Jasper, Pickens county, which showed upon analysis[1] 99.82 per cent. silica and only .03 iron oxide, Fe_2O_3. Doubtless a number of other localities more favorable than the above will be discovered by further prospecting.

1 Analysis by Dr. Edgar Everhart for J. C. Holden, Blue Ridge, Ga.

No especial search for feldspar has been made, but the following localities are mentioned as favorable places for prospecting:

KELL MICA MINE.—A pure orthoclase, potash feldspar, is found at the old Kell mine, 10 miles east of Clayton, Rabun county. The feldspar is quite pure and probably in large quantity, and is associated with a very pure glassy and rose tinted quartz. The present disadvantage is its great distance from a railway line and its inaccessibility.

MILLEDGEVILLE.—Feldspar occurs in large quantity in the cuts of the Georgia Railroad, 3½ miles northeast of Milledgeville. The rock exposed in the cuts consists largely of pink orthoclase feldspar with perhaps 10 to 15 per cent. of quartz. The iron content is also rather high. The deposit is very conveniently located, and it is possible that prospecting in the same neighborhood will reveal material of greater purity.

LAGRANGE.—Large crystals of pink orthoclose feldspar are scattered over the surface, on the Swanson property 2½ miles southwest of LaGrange, Troup county. Until prospecting is done, it is difficult to tell whether the feldspar is derived from a single vein of considerable dimensions or a number of small veins. Black tourmaline, quartz, and muscovite mica are the principal associated minerals. The feldspar is quite pure and free from included quartz; the tourmaline would detract from its value if found to be intimately disseminated through the vein or veins.

OTHER LOCALITIES.—There is some prespect of feldspar being found at the old Turner mine, 5 miles north of Dallas. The feldspar here is largely altered into kaolin, but not entirely so. Feldspar and residual kaolin derived from feldspar were noted on the Davis place, 4 miles southwest of Jasper. Numerous pegmatite veins bearing coarsely crystalline orthoclase, were observed east of Canton, Cherokee county. Jones, Monroe, and Upson counties would not be unfavorable places for prospecting, since numerous pegmatite veins have been observed.

CHAPTER VII

FIRE-CLAYS OF THE TERTIARY FORMATIONS OF THE COSTAL PLAIN

In discussing the kaolins and fire-clays of the Coastal Plain, the description of the clays, have in the previous pages, been confined to the Cretaceous, and the Fall Line belt. The Cretaceous rocks, however, form only a narrow belt, and a comparatively small area, and the great mass of sediments, consisting of sands, clays and limestones, underlying about seven-eights of the area of the Coastal Plain, was deposited during the Tertiary period. The stratigraphy of the Tertiary formation has been previously discussed and will not be taken up here.

The Tertiary deposits of white clays are not as extensive nor as pure as those of the Cretaceous, and it is doubtful whether any of them will be of value in the manufacture of chinaware or other high-grade clay products, but in some localities the clays have high refractoriness, occur in large quantity and may be of future economic importance.

SUMTER COUNTY

Kelley Mill and Copperas Bluff

Some remarkable deposits of white clay occur in the northeast part of Sumter county, and the beds at Kelley Mill and Copperas Bluff, 12 to 16 miles northeast of Americus and about 6 miles east of Andersonville have attracted some attention, and have been the subject of investigation to determine whether they were of value for pottery purposes. The beds probably lie in the Midway formation or Lower Eocene. The purity of the deposits is difficult of explanation, and the conditions of deposition were perhaps similar to those which prevailed during the deposition of the Lower Cretaceous clays, but the clay must have been transported a greater distance.

The purest and most extensive bed which has been found, is located 6 miles east of Andersonville at Kelley Mill on Sweetwater creek, which forms the boundary between Sumter and Macon counties. The following is a geological section of the hillside about 100 yards below the mill:

		Feet
1	Red sand	4
2	Stained clay layer	1
3	Purplish sand	4
4	Stained clay	2
5	Yellow sand	5
6	White, stained clay	3 to 4
7	Pure white, semi-hard clay	8
8	White clay, stained purplish yellow	5
9	Interval to level of creek concealed, but probably clay	5

Beds 1 to 5, of the above section, constitute overburden; beds 6, 7 and 8 constitute one massive bed of clay, which shows no stratification, and the three divisions given, are based upon the color of the clay and are applicable only at the point where the section is made.

Four feet of soft clay is exposed in the bed of the creek at the mill, and it is reported that in building the mill, piles were driven 15 feet into the clay bed without penetrating the full thickness. The clay, which is streaked with iron oxide, is exposed in the bed of the creek for about 100 yards below the mill.

A curious structure, here, is the presence of nodules of clay in the mass of the clay. These nodules are themselves pure clay, and apparently are of the same composition as the mass of the bed; they may vary in size from a pea to 1½ inches in diameter. The nodules wash out of the bed and may be seen in layers and scattered through the sand, which forms the bluff of the creek near its mouth.

A sample of the purest clay found here was selected for tests in the laboratory. The natural exposures indicate that there is a great quantity of clay here, but prospecting will be necessary to determine the available amount of the purest clay, of the purity of the sample tested.

Physical Tests on Kelley Mill Clay

The clay is white when dry; contains only a small percentage of grit, in the form of quartz grains, and is brittle or semi-hard. It slakes readily in water, but crumbles into coarse, angular fragments, which further disintegrate only very slowly; even when finely ground, the clay shows a tendency to be "mealy." In the sieve test, 90 per cent. passed a 150 mesh, when the sample was first lightly pulverized. It has only medium plasticity, and shows a tensile strength of only 14 pounds per square inch.

Its average air shrinkage was 5.7 per cent., and it required 42 per cent. of water for mixing.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	9.1%	white or faint cream
9	11.1%	bluish-gray
13	......	dull gray

It cracks badly in burning and hence is brittle, and the strength of the burned clay is low. It was unfused at cone 32, 3,218° F., and is highly refractory.

The following is a chemical analysis of this clay:

Moisture at 100° C.	9.481
Loss on ignition, water	12.309
Silica, SiO_2	42.590
Alumina, Al_2O_3	33.916
Ferric oxide, Fe_2O_3	.590
Lime, CaO	.000
Magnesia, MgO	trace
Sodium oxide, Na_2O	none
Potassium oxide, K_2O	trace
Titanium dioxide, TiO_2	1.334
Sulphur, S	.000
Phosphorus pentoxide P_2O_5	.000
Total	100.220

The clay is of remarkable chemical purity; it contains only .59 per cent. of iron, Fe_2O_3, and the rather dark color to which it burns, is a phenomenon difficult of explanation, when clays from the Cretaceous with a much higher percentage of iron, and almost the same alumina and silica content burn to a purer white color. Altogether, this is an excellent illustration of how a chemical analysis may be misleading unless supported by physical tests.

In point of refractoriness, it is a high-grade fire-clay, and could possibly be most successfully used in the manufacture of fire-brick, crucibles, etc. Judging from the results from the sample tested, its possibilities for white ware are not very favorable since its burned color is not as pure a white as is demanded by white ware potters. However, should development work prove that the white clay, free from stains, persists over a large area, the results are at least sufficiently encouraging to justify further trials.

On account of a tendency to be "mealy" when slaked, the clay is not likely to be of much value for filling and coating paper. It contains a small amount of "grit," but this could be separated by washing, and would not detract much from the value of the clay, were other properties favorable.

Copperas Bluff

Copperas Bluff is located about 2 miles south of Kelley Mill. The clay is best exposed at the base of the bluff, and near the water level of Flint River. The exposure varies in thickness from nothing to 15 feet for a distance of 200 yards along the base of the bluff, and the full thickness is not seen. A black clay-marl, 15 feet in thickness, lies conformably above the clay; this black clay contains crystals of pyrite and greenish crystals of iron sulphate or copperas, and is reported to have been worked at one time for the copperas which was used as a mordant in dyeing. Above the clay-marl is 20 feet of yellow and orange unconsolidated sand. The white clay is semi-hard, a bluish white in color, and contains only a small percentage of sand; it is minutely jointed, and the joint cracks are filled with a precipitate of iron oxide, deposited by waters infiltrating from the overlying clay-marl and sand formation.

Physical Tests

Color	gray or drab
Plasticity	medium
Water required	43%
Slaking properties	into coarse lumps
Air shrinkage	6.2%
Tensile strength	37 lbs. per sq. in.
Cone 4—	
Fire shrinkage	11.9%
Color	cream
Cone 13—	
Fire-shrinkage	13.4%
Color	dark gray to buff
Fusing point	unfused at cone 30

The fire shrinkage is high, and the clay burns to a very dense body at a low temperature, with noticeably less cracking than the Kelley Mill clay.

The following is a chemical analysis of this clay.

Moisture at 100° C.	2.617
Loss on ignition, water	13.648
Silica, SiO_2	43.756
Alumina, Al_2O_3	36.095
Ferric oxide, Fe_2O_3	1.598
Lime, CaO	.259
Magnesia, MgO	.134
Sodium oxide, Na_2O	.291
Potassium oxide, K_2O	.030
Titanium dioxide, TiO_2	.827
Sulphur, S	.201
Phosphorus pentoxide, P_2O_5	.032
Total	99.488

As in the case of the Kelly Mill clay, the Copperas Bluff clay can probably be used most successfully in the manufacture of refractory wares, as fire-brick, etc. The excessive shrinkage may be counteracted by the addition of sand or grog.

On account of the dark color to which the material burns, it is not likely to be of any value for chinaware.

Its dark color and poor slaking properties, preclude its use as a paper filler.

Both the Kelley Mill and Copperas Bluff clays are at present poorly located in regard to transportation facilities, being respectively 6 and 8 miles from the Central of Georgia Railway. However, it is reported that a railway, in the process of construction, is to pass quite near both localities, and in this event, the value of the clay deposits will be greatly increased. While there is little probability that the clays at Copperas Bluff and Kelley Mill are parts of the same bed, and underlie continuously the intervening area, still, the clays occur in quantity sufficient for any clay working purpose for which they may be adapted.

Other white clay deposits will probably be found in the southern part of Macon county, and at other localities on Sweetwater Creek above Kelley Mill. A deposit is known to occur on the property of Zach Childers, in Schley county, 7 miles southeast of Ellaville. It is quite similar in its properties to the clay at Kelley Mill. Little or no prospecting has been done to determine the extent of the bed, or whether there is any large quantity as pure as indicated by the following analysis of a small sample sent to the State Geological Department by the owner of the property:

Analysis of Clay from Zach Childers, Ellaville

Moisture at 100°C	13.38
Loss on ignition, water	12.14
Silica, SiO_2	38.55
Alumina, Al_2O_3	33.33
Ferric oxide, Fe_2O_3	.85
Manganous, oxide, MnO	trace
Lime, CaO	none
Magnesia, MgO	.04
Soda, Na_2O	.03
Potash, K_2O	trace
Titanium dioxide, TiO_2	1.47
Total	99.79

RANDOLPH COUNTY

Pockets of white clay occur in the Midway formation in the northern part of Randolph county. Some of these deposits are quite pure, but the greater part will be found sandy and stained with iron, or possessing a uniform cream color. A peculiar property is their very hive fire shrinkage. Some of these deposits may be of future value as fire clays.

A sample of white clay occurring on the upper Lumpkin public road, on the property of A. J. Moye, 5½ miles north of Cuthbert, was tested in the laboratory.

Physical Tests on Moye Fire-Clay

The dry clay is a light cream color; it has excellent plasticity, and required 52 per cent. of water for mixing. Its air-shrinkage was 6 per cent.; tensile strength very low, probably not exceeding 10 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	10.8%	almost white
8	21.8%	dark gray
9	22.2%	dark gray
15	......	blue or dark gray

The fire-shrinkage is unusually excessive, and the clay cracks badly in burning. At cone 9, it burned to a very dense stony body, almost impervious; at cone 15, very dense, but could hardly be called vitrified.

The following is a chemical analysis:

Moisture at 100°C	1.317
Loss on ignition, water	13.375
Silica, SiO_2	44.600
Alumina, Al_2O_3	38.485
Ferric oxide, Fe_2O_3	1.020
Manganous oxide, MnO	trace
Lime, CaO	.000
Magnesia, MgO	.050
Sodium oxide, Na_2O	.032
Potassium oxide, K_2O	.116
Titanium dioxide, TiO_2	1.265
Sulphur, S	.000
Phosphorus pentoxide, P_2O_5	.000
Total	100.260

This clay will doubtless be highly refractory, and may possibly be suitable for such purposes as paper filling when washed, but it is not a china clay.

QUITMAN COUNTY

Pockets and layers of white clay were noted in the cuts of the Central of Georgia Railroad between Hatcher Station and Georgetown. Near the 134 and 135 mile poses, pockets or lenticular layers of white or light colored clays occur in the massive sands, and are closely associated with thin layers, crusts and concretions of limonite. These clays may be adapted for fire-clay products, but are not likely to be of value for the higher grades of clay wares. The clays are soft and plastic, and will likely be found of high refractoriness.

A good exposure of gray, plastic, sandy clay occurs in the railroad cut at Wire Bridge station.

STEWART COUNTY

Pockets and lenticular layers of white clays, together with deposits of waxy impure clays and soft shale clay, occur in the Midway formation in the southern part of Stewart county.

A bed of white clay, 10 feet thick, was observed in the public road to Cuthbert, 8 miles south of Lumpkin. A small sample from this place tested in the laboratory, showed good plasticity, slaked readily in water, and showed only a small percentage of sandy impurities. Its air-dried tensile strength was low; air-shrinkage 4.9 per cent. It burned almost white at cone 4, but cracked badly in burning. At cone 9, it burned to a gray color. Its fusing point was above cone 32, 3,218°F.

Small samples of pure white clay may be obtained in this locality and elsewhere in the county, but the extent of these pure clays should be carefully investigated, as the beds as a whole, will generally be found to contain a high percentage of iron.

JEFFERSON COUNTY

A very hard flint clay, lying in the lower part of the Claiborne formation, was found along Reedy Creek in the northeastern part of Jefferson county, and some occurrences were also noted in the adjoining county of Richmond. This clay is bluish white in color, entirely free from sandy particles, and much harder than the flint clays of the Cretaceous. It breaks with an angular or conchoidal fracture, and has little or no plasticity even when finely ground. It showed an air-dried tensile strength of 25 pounds per square inch. It burned to a pure brilliant white, at cone 6. This clay was noted as occuring in considerable quantity near R. R. Hatcher's mill on Reedy Creek, 5 miles north of Wrens.

A very plastic fine grained soft clay occurs with the hard clay; it burns to a gray-buff and is vitrified at cone 6. It showed an air dried tensile strength of 85 pounds per square inch. The quantity of this clay is probably small.

The following is a chemical analysis of the flint clay occurring at Hatcher Mill:

Moisture at 100° C.	4.15
Loss on ignition	8.71
Silica, SiO_2	65.21
Alumina, Al_2O_3	21.62
Iron oxide, Fe_2O_3	.48
Lime, CaO	none
Magnesia, MgO	.10
Soda, Na_2O	trace
Potash, K_2O	trace
Titanium dioxide, TiO_2	.08
Total	100.35
Soluble silica	43.90
Quartz	3.99
Combined silica	17.32

Rational analysis:

Feldspar	none
Quartz	3.99
Clay substance	96.01
Total	100.00

The high percentage of soluble silica shown is very unusual.

THOMAS COUNTY

Some white clays of high refractoriness were noted in the Altamaha formation, the most widespread formation of the Coastal Plain, but are of no more than local value. In general the only fluxing element, occurring in large percentage in the clays of the Altamaha formation, is iron. Even in the very impure brick clays, the amount of lime, magnesia and alkalies is small. Deposits of clay were noted near Thomasville, containing only a small percentage of iron, and a sample was collected for tests. The sample was obtained from the pit of the Arnold Brick Company, 2 miles north of Thomasville.

Physical Tests on a White Clay from Thomasville

The clay is plastic, very stiff and tenacious, fine grained and contains only a small percentage of sandy impurities; its air dried tensile strength was about 30 pounds per square inch; air shrinkage 5.9 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Condition*
03	7.1%	checks badly
1	......	warped and cracked
4	9.0%	cracked badly
14	12.1%	vitrified, warped, cracked

The burned color is from almost white to a dark leather buff. It is very obvious that the clay could not be used alone, on account of its warping and cracking in burning, but it would be necessary to mix with it a sand or sandy clay.

It was unfused at cone 31, 3,182°F, and is in point of refractoriness, a good fire-clay. The following is a chemical analysis of this clay:

Moisture at 100° C.	.865
Loss on ignition, water	11.910
Silica, SiO_2	50.480
Alumina, Al_2O_3	31.480
Iron oxide, Fe_2O_3	2.720
Lime, CaO	none
Magnesia, MgO	.094
Soda, Na_2O	.045
Potash, K_2O	.216
Titanium dioxide, TiO_2	2.530
Sulphur, S	trace
Total	100.340

A similar deposit of white clay was observed in a cut of the Atlantic Coast Line Railroad at Lambville, 6 miles east of Thomasville.

CHAPTER VIII

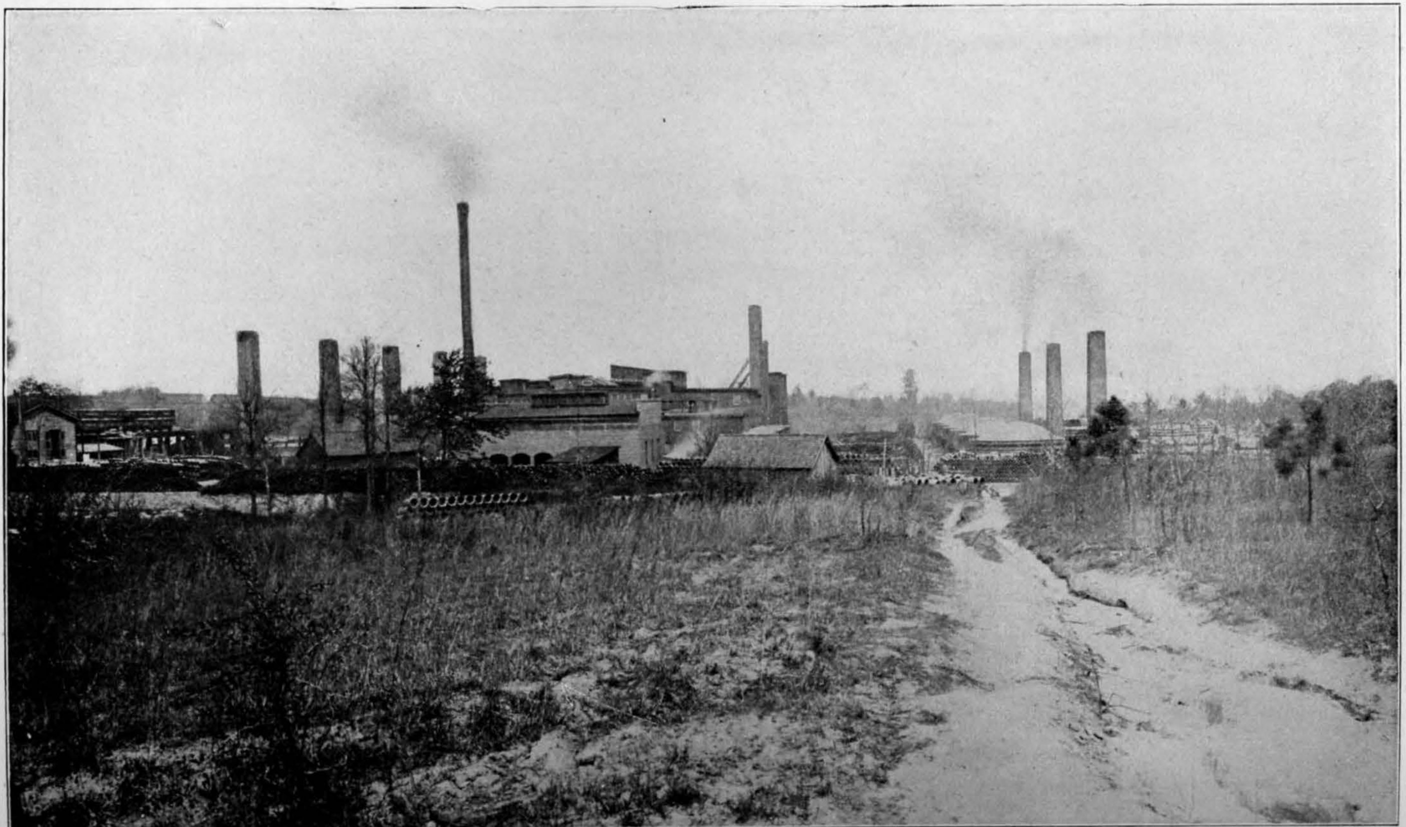
KAOLINS OF THE PIEDMONT REGION

The kaolins of the Piedmont region are residual in origin and have been derived from the weathering and decomposition of pegmatite granites. That is, these kaolins occupy the positions where they originated, or are clays formed *in situ* and are thus contra-distinguished from the kaolins and fire-clays of the Coastal Plain, which have been transported from their places of origin and are sedimentary deposits. The term *pegmatite* means coarse grained granite, composed principally of quartz and feldspar. Throughout the Piedmont region of Georgia, pegmatites occur as dikes and intrusive veins, sheets, and pockets, cutting other igneous rocks and metamorphic schists. The dikes and veins vary from a few inches to several feet in width, and may be entirely disintegrated and decomposed to great depths, or on the other hand, may be fresh and unweathered, and in such cases when the crystallization is coarse, are possible sources of feldspar.

Very little prospecting for residual kaolins has been done in Georgia, and there are only a few deposits known which give promise of being of any economic importance.

GREENE COUNTY

There is a residual deposit of kaolin on the property of W. S. and T. J. Hester, 4 miles northeast of Union Point. The kaolin results from the weathering of a pegmatite dike, 15 or 20 feet in width. The dike has a northwest and southeast direction; there is a natural exposure of the kaolin in



FACTORY OF THE GEORGIA VITRIFIED BRICK AND CLAY COMPANY, CAMPANIA, NEAR HARLEM, COLUMBIA COUNTY, GEORGIA.

a gully for a distance of 150 feet, and the dike has been penetrated by a shaft 40 feet deep from which two drifts have been driven longitudinally 50 feet. The depth to which weathering has extended, has not been determinea.

A small amount of kaolin is mined here and is reported by the owners of the property as being shipped to Providence, R. I. It is unwashed and is hauled to Union Point by wagon.

The following is a chemical analysis of the crude kaolin:

Moisture at 100° C	1.219
Loss on ignition, water	6.224
Silica, SiO_2	70.313
Alumina, Al_2O_3	19.719
Iron oxide, Fe_2O_3	.797
Lime, CaO	.078
Magnesia, MgO	trace
Manganous oxide, MnO	.031
Soda, Na_2O	trace
Potash, K_2O	1.683
Titanium dioxide, TiO_2	.091
Total	100.155

Rational analysis:

Feldspar	0.674	Sand	48.721
Quartz	48.047		
Clay substance			51.279
Total			100.000

A sample of the crude kaolin burned white at cone 5 and a faint cream at cone 13. It was fused at cone 30.

The sandy impurities are in a very fine state, are mainly quartz and muscovite mica, and one is deceived as to the amount of sand present.

A further exposure of residual kaolin was noted about 50 yards southeast of the shaft, but the quantity has not been investigated, but it does not seem to be of much promise. A short distance east, undecomposed pegmatite was found in sinking a well on the Thornton place.

About one mile northwest of the Hester place, there is a natural exposure of residual kaolin on the old Tuggle place. The kaolin is exposed along a small branch for a distance of about 100 feet. No attempt has been made to determine the extent of the vein.

PAULDING COUNTY

There is some prospect for residual kaolin at the old Turner mica mine, 5 miles north of Dallas. The kaolin has resulted from the decomposition of a coarse grained felspathic granite, consisting principally of quartz, large crystals of potash feldspar and muscovite mica. The quartz is the predominant mineral, and occurs in large masses, and might be of some commercial value within itself; the feldspar is pure white, and is not in all places entirely decomposed, but only partially so, a shaft has been sunk 87 feet, and the granite has showed decomposition to this depth; the mica occurs in large flakes, and is remarkably clear and free from inclusions between the laminæ, but from the casual examination made, would seem to be rather too scattered to be mined profitably. The kaolinized area could not be determined with much accuracy during the time of the writer's inspection, but it is probably small. Altogether the prospect is favorable, though its present distance from a railway is a great disadvantage.

PICKENS COUNTY

About 4½ miles southwest of Jasper, there is an area of diabase and pegmatite dikes cutting metamorphic schists. On the property of Marion Davis, there is a pegmatite which seems to be extensively kaolinized. The feldspar is a potash feldspar, pure white in color. A pit has been sunk into the vein, near Marion Davis' house, to a depth of 20 feet, and it is reported that the decomposition was as complete at this depth as at the surface, and that there was no evidence of the vein pinching out; the vein showed a width of about 10 feet and has an almost east-west direction.

On the Joe Davis property, about $\frac{1}{4}$ mile east of the M. Davis place, two pits have been sunk into a vein of kaolinized pegmatite. The feldspar is not as completely decomposed as at the M. Davis place, and mica is more abundant.

On the adjoining property eastward, outcrops of kaolin and feldspar are said to occur. The prospects for both kaolin and feldspar, in commercial quantity, in this locality, are favorable.

Other Localities

During a trip through the mountainous region of North Georgia, numerous exposures of dikes, veins, sheets and pocketc of kaolinized granites were observed, but until this region is opened up by railways, any large deposits that might occur, are valueless.

Near Nacoochee in White county, a kaolinized granite is conspicuous.

There is some probability of residual kaolins being found in proximity to the Tallulah Falls Railroad in the northern part of Rabun county, and also along the line of the Southern Railway in Banks, Stephens and Habersham counties.

In almost any county in the Piedmont region, kaolinized granite veins may be observed, but in most instances the veins are only a few inches or a foot or two in width. In the vicinity of Atlanta, veins and pockets of kaolin can be observed, cutting the schists in numerous cuts and excavations, but the quantity available is nowhere great.

Some rare clay minerals allied to the kaolinite, occur throughout the Piedmont region, but are only of mineralogical interest. A beautiful pink halloysite has been found near Lakewood, a suburb of Atlanta. This has a waxy luster, is brittle, breaks with a conchoidal fracture, and shows no plasticity. On being heated to ignition, it lost 15.43 per cent. of its weight.

Some very interesting occurrences of halloysite and allied minerals were observed near Burwell in Carroll county. These minerals occur in thin veins of variable thickness, from ¼ to 3 inches, and in color are pure white, yellow, red, brown and green. The veins occur in a disintegrated granite, and are horizontal, and in one instance were observed cutting at right angles the planes of schistosity of a hornblende granite gneiss. Some particles of quartz are associated with the veins of halloysite, and they show slickensided surfaces. The origin of halloysite is obscure, but it appears that it has resulted from the alteration of the feldspar of intruded veinlets of igneous origin.

The greenish and yellow-green variety has a hardness of 2.5 to 3, receives a good polish, and may be a new variety, although no chemical analyses have been made. It is infusible before the blowpipe, and has a specific gravity of 2.2; it is not porous and does not adhere to the tongue; the color is due to iron which seems to be in chemical combination with the aluminum silicate.

A specimen of lustrous white halloysite has been sent to Geological Department from near Dahlonega, Lumpkin county, but nothing is known by the writer as to its geological occurrence.

CHAPTER IX

KAOLIN AND FIRE-CLAYS OF THE PALEOZOIC REGION, OF NORTHWEST GEORGIA

The stratigraphy of the clays of this region has been previously discussed; the rocks consist of limestone, shales and sandstones which range in age from Lower Cambrian to the Coal Measures of the Carboniferous.

The kaolins and fire clays may be divided into three classes, on a basis of mode of occurrence and origin:

1. Those clays associated with the bauxites and certain deposits of iron ore. 2. Residual deposits, derived chiefly from the decay of limestones. 3. Sedimentary deposits, beds of fire clay associated with seams of coal, and certain clay shales semi-residual in character.

The clays associated with bauxite, aluminum ore, are the most refractory, and the purest clays will certainly be found to be of considerable commercial importance, although they have been almost entirely neglected heretofore. These clays together with very low grade bauxites, which also have a value for fire-clay products, occur in great abundance, associated with the bauxite deposits of Floyd, Bartow, Polk and Chattooga counties, and are probably closely related in origin to the bauxites. Some of the clays tested during the progress of the work on this report, were found to approach kaolins in chemical composition, and may have some value, in limited quantities, for use in the manufacture of the higher grades of pottery. Others showed a higher percentage of alumina than is found in kaolins, and evidently contained a small percentage of bauxite, $Al_2O(OH)_4$, which contains 73.9 per cent. of alumina, whereas kaolinite, the assumed base of kaolins, contains only 39.8 per cent. of alumina.

The clays occur associated with the bauxites, which are scattered, pocket deposits more or less circular in form and of small area, as clay "horses," dikes or veins, and as great irregular shaped masses inclosing small bodies of bauxite. The clay is massive in structure; and does not occur in the form of stratified deposits, but in places there is a simulation of bedding, alternating layers of different colored clays and of bauxite.

The contact between the clay masses and the bauxite may be sharp, or the two may grade into each other, pure bauxite grading into lean bauxitic clay. The clay may occur as "horses" or dikes, cutting the ore bodies, and may be vertical and have a width of a foot or two, or as much as 30 feet and often continues to a depth of 40 or 50 feet, or the clay may occur as great masses inclosing bodies of ore, that is, it may be a bauxitic clay, containing scattered pisolites of bauxite. The walls of the ore deposits may be clay and show a dip of 25° to 45°, but as mentioned above, there is apparent bedding in some of the pits and layers of clay and bauxite, almost horizontal, may be superimposed upon each other. As may be inferred from the above description, the clay and the bauxite are intimately associated.

The origin of the clay is similar to that of the bauxite. Dr. C. W. Hayes who made a careful study of the Georgia and Alabama bauxites, has advanced the most satisfactory theory of their origin.

The theory is in brief as follows: The aluminum was derived from a great thickness of aluminous shales, underlying the limestone formation in which the bauxite deposits occur, by the action of sulphuric acid (which was formed by the oxidation of pyrites occurring in the shale), which decomposed the silicates of aluminum forming alum and sulphate of aluminum. Ascending currents, carrying these salts in solution, reached the surface through fissures near fault lines forming thermal springs. During their upward passage, the salts were decomposed by coming in contact with the limestone, and finally deposited as aluminum hydroxide, in the form of a gelatinous precipitate, at the vents of springs.

There is no evidence from field study, that the clays are not contemporaneous with the bauxite, and a theory accounting for the latter must be applicable to the former. It is most probable then, that these clays are chemical deposits.

An idea of the quantity of the clay may be obtained from the description of the various mines. Certainly the quantity at any locality is sufficient for the needs of any clay working establishment, located near the deposit or for the purposes of mining and shipment to other localities. Many of the larger pits through the Georgia bauxite region are as much as 200 feet in diameter or length, and 30 to 80 feet in depth. And as the light colored and mottled clays and the lean bauxitic clays form by far the greater precentage of the material in such pits, an idea of the quantity is readily inferred. As mining is at present conducted, the clay and lean bauxitic clay are obstacles in mining, and are either left in the pits or thrown on the dumps as waste.

These clays are of various colors, determined by the amount and distribution of iron oxide, white, mottled, pink, yellow and red. The white and pink are freest from impurities, but even the highly colored clays, when containing bauxite, are highly refractory. Some of the white clays show a fair plasticity, but in the greater part of the clays, there is a prevailing lack of plasticity, which is much to their disadvantage. The air dried tensile strength is low; in none of the samples tested by the writer, exceeding 15 pounds per square inch. The air shrinkage is usually low, and the fire shrinkage high, and when burned alone, the clays crack badly, especially the bauxitic clays. In point of refractoriness, these clays are excelled by none in the State, and in this property perhaps their chief value lies. Some of these clays tested in a Deville furnace, were unfused at cone 36, 3,362°F. The high percentage of alumina, partly bauxite, will make basic brick, which should make such clays valuable for certain uses. The lean bauxitic clays and the low grade bauxites would perhaps have to be calcined (elimination of the combined water or water of hydration) before burning.

All of the mines examined contained white clays. The bauxite has been worked out of some, but the clays remain as a potential source of wealth.

Some white or light colored clays are associated with the brown iron ores of Polk, Floyd and Bartow counties. These occur in great quantity as clay "horses," irregular humps or dikes, intersecting the iron ore deposits. They are not as pure as the bauxite clays, and contain often a high percentage of sand, and may contain scattered fragments of chert, and siliceous iron ore. They are probably residual in origin, being derived chiefly from the decay of limestones and differ in origin from the iron ores with which they are associated. Like the bauxitic clays, they have low air dried strength, though their plasticity is better. In point of refractoriness, none of them are No. 1 fire-clays, and none are sufficiently pure to be called kaolins. They offer a possibility for paving blocks and might in some instances be suitable as an ingredient of stoneware and terra cotta mixtures.

The second class, the residual clays, are derived from the decay of the Knox dolomite. These clays are white or light colored, occur in restricted areas or pockets, and are highly siliceous, containing coarse fragments of chert, and very fine sand. At no place observed by the writer during field work, did deposits appear to be worth washing for the clay. These deposits can be used in the manufacture of fire-brick, but the refractoriness of such brick lies in the coarse chert and not in the clay; the principal use of the clay is as a bond for the chert fragments, and the product is a silica brick.

The third class mentioned, the sedimentary fire-clays, are relatively of little importance. There are flint and plastic clays underlying the coal beds of Dade and Walker counties, but these do not possess high refractoriness, and so far as is known, do not occur in great quantity, or have any special properties which make them of commercial importance.

An altered Silurian shale occurring in Polk county, has proved to have some value as a refractory clay.

The description of the fire-clay deposits of the Paleozoic region, shall be taken up by counties and localities.

FLOYD COUNTY

The most valuable fire-clays of this county are the bauxite clays. Samples for laboratory tests were collected from the property of the Republic Mining and Manufacturing Company in the Hermitage district, from the old Watters Bank, 5 miles northeast of Rome, belonging to the National Bauxite Company, and from the Cave Spring district and other places in the southern part of Floyd county.

HERMITAGE DISTRICT.—Tests were made on a sample of lean bauxitic clay from the "103" mine, *lot 103, 23rd district, 3rd section.* This clay is soft, white or mottled and is 35 feet or more in depth. It shows very poor plasticity, and low tensile strength. Its air shrinkage was 2 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Condition*
4, 2,210°F.	4.7%	soft
13, 2,534°F.	5.5%	soft and friable
36, 3,362°F.	.....	unfused

It shows very low fire-shrinkage, and burns white. It is unfused at cone 36, and should be suitable for high grade fire-brick. The only common fluxing impurity is a small percentage of iron.

A sample of low grade bauxite from near the old Stockade Bank *lot* 21, 23*rd district,* 3*rd section,* tested in a Deville furnace, was unfused at cone 36, 3,362°F. This material is hard and iron stained, and contains a high percentage of alumina, Al_2O_3, in the form of bauxite. It would probably have to be calcined before it could be successfully burned. Judging from the records of a number of test pits, it evidently occurs in large quantity.

The following is an analysis of white clay, from this same lot, given by Dr. J. W. Spencer[1] in his report on the *Paleozoic Group of Georgia.*

There is no record, however, of the locality on the lot, or description of the deposit from which the sample was taken.

Al_2O_3	38.60
Fe_2O_3	1.45
K_2O	0.09
Na_2O	0.02
MgO	0.30
TiO_2	1.95
SiO_2 (combined)	40.40
SiO_2 (free sand)	0.80
H_2O (combined)	16.35
H_2O (hygroscopic)	0.35
Total	100.31

At the Church, Holland Hill, and Holland Spring banks, white, lean and granular bauxitic clays occur in great quantity, and have been almost valueless heretofore. The Church bank and the Holland Spring bank have been worked to a depth of 75 feet; more or less structureless white clay has been encountered for the whole depth. The clays are soft, or pinkish, and mottled, poorly plastic, and have low air

1. Geol. Surv. of Ga., 1893, p. 281.

dried strength. A sample from the Holland Hill mine tested for its refractoriness, was unfused at cone 36, 3,362°F.

The following analysis by Watson[1] of the soft, white bauxitic clay in the Church bank will give some idea of the character of the clay:

SiO_2	20.46
TiO_2	9.82
Fe_2O_3	0.28
Al_2O_3	46.92
H_2O at 100° C.	0.34
H_2O (combined)	21.68
Total	99.50

A large percentage of the alumina of the analysis is evidently derived from bauxite. It will also be noted there is a very high percentage of titanium dioxide, 9.82 per cent.; it is not believed that this occurs in the form of rutile, and its fluxing effect is doubtful. Such clays should be suitable for basic fire-brick, though they would have to be calcined.

WATTERS BANK.—A sample was selected from the south pit of the National Bauxite Company, located 5 miles northeast of Rome, and about 1½ miles east of Berwin Station on the Southern Railway. Clay occurs here in great quantity, cream color, pink, and highly colored, with more or less disseminated bauxite.

Physical Tests on Soft Pink Clay

Color	faint pink when dry, cream color when wet
Plasticity	very little
Water for mixing	40%
Air shrinkage	5.4%
Tensile strength	12 lbs. per sq. in.
Specific gravity	2.45
Slaking	slakes into small granules
Cone 4—	
Fire shrinkage	3.8%
Color	pure white
Condition	cracked, very friable
Hardness	not steel hard

1. Geol. Surv. of Ga., Bulletin 11, p. 65.

Cone 9—	
Fire shrinkage	9.5%
Color	pure white
Condition	cracked, friable
Hardness	not steel hard
Cone 11—	
Fire shrinkage	no measurement
Color	white
Condition	cracked to pieces
Cone 16—	
Fire shrinkage	16.3%
Color[1]	slight cream
Condition	steel hard, not vitrified
Fusion point	unfused at cone 36

The clay is amorphous and free from pisolites of bauxite; it is fine grained and free from sand, but not as large a percentage will pass a 200 mesh sieve, as in the Dry Branch clays, because the bauxitic clay does not disintegrate as finely in water, but crumbles into small angular lumps.

It is a very high grade clay in point of refractoriness, but would have to be calcined before use, on account of its cracking in burning.

The following is a chemical analysis of the clay:

Moisture at 100° C.	.240
Loss on ignition, water	21.770
Silica, SiO_2	25.830
Alumina, Al_2O_3	48.220
Ferric oxide, Fe_2O_3	.850
Manganous oxide, MnO	.000
Lime, CaO	.000
Magnesia, MgO	.181
Sodium oxide, Na_2O	.148
Potassium oxide, K_2O	.194
Titanium dioxide, TiO_2	2.530
Sulphur, S	.000
Phosphorus pentoxide, P_2O_5	.000
Total	99.963

Rational analysis:

Feldspar	.56	Sand	.62
Quartz	.06		
Clay substance			99.38
Total			100.00

1. The sample was burned in the open furnace and exposed to oxidizing conditions.

The high percentages of water and alumina, Al_2O_3 are due to the large amount of bauxite which the clay contains.

The following are partial analyses by Dr. T. L. Watson[1] of clay from the "horses" at the Maddox bank, *lot 138, 23rd district 3rd section.*

	North Pit			*South Pit*	
Al_2O_3	40.60	46.33	45.05	.....	.....
Fe_2O_3	.99	.....	.....	.....	.....
Insol. matter	43.30	43.75	37.42	31.80	38.80

WEAR MINE.—A sample of white clay was obtained from the old Wear mine about 1½ miles southwest of Reesburg, and near the old Minter mines.

Physical Tests

Plasticity fair; tensile strength very low; air shrinkage 3.5 per cent.; burned color, white, up to cone 15.

Cone	*Fire-Shrinkage*	*Condition*
4	6.6%	soft, cracked
15	14.8%	cracked

The following is a chemical analysis of white clay from the Wear mine:

Moisture at 100° C.	0.291
Loss on ignition, water	16.599
Silica, SiO_2	37.060
Alumina, Al_2O_3	40.272
Ferric oxide, Fe_2O_3	1.568
Lime, CaO	trace
Magnesia, MgO	.182
Sodium oxide, Na_2O	.106
Potassium oxide, K_2O	.151
Titanium dioxide, TiO_2	3.680
Total	99.909

Amounts insoluble in sulphuric acid:	
Alumina	.090
Ferric oxide	....
Lime	....
Magnesia	....
Sodium oxide	trace
Potassium oxide	trace

BOBO BANK.—The following is an analysis[2] of a pure

1. Ga. Geol. Surv. Bulletin 11, p. 72.
2. 2. T. L. Watson, Geol. Surv. Ga., Bulletin 11, p. 97.

white clay from the Bobo bauxite pit, on *lot* 534, *3rd district, 4th section.*

SiO_2	43.31
TiO_2	none
Fe_2O_3	none
Al_2O_3	43.08
H_2O at 100° C.	.43
H_2O (combined)	14.12
Total	100.94

Such a clay as this would burn pure white at any temperature, and its fusing point would be expected to be above cone 36.

Cave Spring.—Samples of bauxite clays were collected and tested in the laboratory of the Survey, from the Hampton and Reese mines, located respectively 3 miles south and 2 miles southeast of Cave Spring. These mines are the property of the National Bauxite Company. At the Hampton mine, white and pink clays approaching kaolins in chemical composition, are intimately associated with the bauxite. At the time of my visit, the mine had just been opened up, and no large exposures could be seen, though doubtless these clays will be found in great quantity.

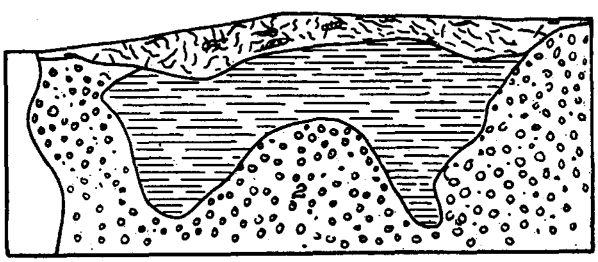


Fig. 9.—Sketch Showing Relation of White Clay to Bauxite, in one of the Bauxite Mines of Northwest Georgia; the White Clay being Represented by the broken Horizontal Lines and the Bauxite by Dots.

Tests on Hampton Mine Clay

The clay is a beautiful pink in color, soft, fine grained but of only medium plasticity, although it is not *mealy* as are some of the lean bauxitic clays from other localities. Its tensile strength is low; air shrinkage 2.8 per cent.

Burning Tests

Cone	*Fire-Shrinkage.*	*Color*	*Condition.*
5	9%	white	checked
8	10.8%	white	cracked
11	12.9%	white	cracked
15	......	dull white	cracked badly

Burned at cone 5 and glazed, it showed no color. It was unfused at cone 32, 3,218°F., and will probably stand a much higher temperature.

The following is a chemical analysis of a pink clay from the Hampton mine:

Moisture at 100° C	.27
Loss on ignition	13.76
Silica	44.23
Alumina	38.95
Ferric oxide	.93
Lime	.00
Magnesia	.07
Sodium oxide	.01
Potassium oxide	.11
Titanium dioxide	1.84
Sulphur	.00
Phosphorus pentoxide	.00
Total	100.17

Rational analysis:

Feldspar	.85	Sand	.85
Quartz	.00		
Clay substance			99.15
Total			100.00

Tests on Reese Mine Clay

This is a fine grained cream colored clay, containing a small amount of sand. It has medium plasticity and low tensile strength; its air shrinkage is 3 per cent.

Burning Tests

Cone	*Fire Shrinkage*	*Color*	*Condition*
5	7.7%	white	friable
8	9.9%	white with black specks	friable
12	11.1%	cream	friable

The clay is unfused at cone 33, 3,254°F., and will probably stand cone 36. It does not burn to a dense body, except at very high temperatures, and it would probably be necessary to mix a dense burning clay with it.

The following is a chemical analysis of the Reese mine clay:

Moisture at 100° C	2.174
Loss on ignition	13.657
Silica	43.350
Alumina	38.055
Ferric oxide	.845
Manganous oxide	trace
Lime	.000
Magnesia	.000
Sodium oxide	trace
Potassium oxide	trace
Sulphur	.000
Phosphorus pentoxide	trace
Titanium dioxide	1.950
Total	100.031

In all of the bauxite mines of the county visited by the writer, bauxitic clays suitable for refractory purposes occurred in abundance. At many, all of the high grade bauxite has been worked out, and the pits abandoned. The clay, however still remains a possible source of value. The location of the bauxite workings may be seen by reference to map opposite page 16, Bulletin 11, Ga. Geol. Surv.

BARTOW COUNTY

Some highly refractory bauxitic clays occur in the northwestern part of this county.

Julia Mines.—The Julia mines are located one and one fourth miles southwest of Barnsley on *lot 117 16th district, 3rd section,* Bartow county, and are the property of the Republic Mining and Manufacturing Company. The workings here are quite large, and a great amount of clay could be secured without much difficulty. At the time of my visit, 40 feet of clay with pockets of bauxite, could be seen in the

PROSPECTING A DEPOSIT OF SEDIMENTARY KAOLIN, CENTRAL GEORGIA.

west side of the pit. The clay here does not seem to be as pure, however, as at some other localities.

Tests on the Julia Clay

The clay is a pink in color; has very little plasticity and low tensile strength. Its air shrinkage was 4.7 per cent. Its fusing point is near cone 36, 3,362°F.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
4	14.3%	cream with iron specks
8	14.6%	cream with metallic specks

Unless carefully burned, it cracks badly. Examined under the microscope, it was composed of white, flaky bunches of clay, angular particles of quartz, and scattered iron oxide grains. No other minerals were recognizable, although there are some minute flakes which may be mica. No titanium bearing mineral could be recognized, although as will be seen by the accompanying analysis, the clay contains, 2.206 per cent. of TiO_2. The titanium dioxide is probably in combination with the bauxite or the aluminum silicate, and its presence is thus connected with the origin of the clays.

The following is a chemical analysis of the Julia clay:

Moisture at 100° C.	0.407
Loss on ignition	13.819
Silica	43.772
Alumina	38.726
Ferric oxide	1.119
Lime	.020
Magnesia	.038
Sodium oxide	.168
Potassium oxide	.077
Titanium dioxide	2.206
Sulphur	.010
Phosphorus pentoxide	none
Total	100.362

Amounts insoluble in suphuric acid.

Alumina	.082
Ferric oxide	.048
Lime	trace
Magnesia	trace
Sodium oxide	.036
Potassium	none

Rational analysis:

Feldspar	0.512	Sand	5.119
Quartz	4.607		
Clay substance			94.881
			100.000

SHEET MINE.—This mine is located about 3 miles south of Adairsville, on *lot 22, 16th district, 3rd section.* As much as 25 feet of white clay was exposed here at the time of my visit, and a shaft in the bottom of the pit 15 feet deeper, showed bauxitic clay. There are small veins of remarkably pure, lustrous white kaolin, and an occurrence of halloysite was also noted.

Bauxitic clays were noted as occurring at the old Mary and Connesenna mines, and halloysite was abundant at the former place. The clays are white and varicolored.

HOLT MINE.—The following analysis is given by Watson[1] of a soft bauxitic clay from the Holt mine, *lot 65, 16th district, 3rd section.*

SiO_2	40.16
TiO_2	9.25
Fe_2O_3	trace
Al_2O_3	35.80
H_2O at 100° C.	.50
H_2O (combined)	15.05
Total	100.76

The analysis indicates a very highly refractory, white burning clay.

POLK COUNTY

There are both bauxite and iron ore clays in this county. Bauxitic clays occur in great abundance in the pits in the northern part of the county adjacent to the Floyd county deposits, and will probably be found to have similar properties to those deposits.

1. Geol. Surv. Ga. Bulletin 11, p. 83.

The following is an analysis of a clay sent to the Geological Department by Mr. H. N. Van Devander of Cedartown, and reported as occurring 1½ miles north of Esom Hill on the Love place.

H_2O	0.54
Ignition	14.08
SiO_2	44.66
Al_2O_3	38.49
Fe_2O_3	.54
MnO	.25
TiO_2	1.49
Total	100.05

The analysis indicates a clay of high refractoriness, and it would probably be best suited for fire-clay purposes; the percentage of free silica or sand is quite small. The small sample examined, showed poor plasticity, and would require being mixed with a stronger clay.

White or varicolored clays are found in most of the iron mines of the county, but these clays do not approach in purity and refractoriness the bauxitic clays of the Paleozoic area.

OREMONT.—The white clays found in the iron ore pits at this place, are usually lean or sandy. Clay free from iron ore and siliceous fragments occurs in great quantity, and could be easily mined in connection with the iron ore. The clays are probably residual in origin.

A sample selected from the main workings, was tested in the laboratory with the following results:

Physical Tests

Plasticity poor; tensile strength 17 pounds per square inch air shrinkage 3.7 per cent. Its drying qualities are good. Under the microscope, it was seen to consist of angular quartz grains of variable size, abundant flakes of mica, probably muscovite, and aggregates of clay particles. Iron oxide occurred as a yellow and red coating over the quartz and clay particles.

Cone	*Fire-Shrinkage*	*Condition*
4	11.1%	vitrified
15	11.4%	vitrified, warped

Burning Tests

It was melted into a glass at cone 28, and its fusing point is probably much lower. In point of refractoriness, it is at best only a low grade fire clay. The writer suggests that there is a possibility of making paving blocks from this clay alone, or of this clay and the nearby shales, and it might also be used in terra cotta and stoneware mixtures. It burns to a dark buff color. Its defect is poor plasticity and dried strength.

The following is a chemical analysis of this clay:

Moisture at 100° C.	0.608
Loss on ignition, water	5.307
Silica, SiO_2	58.880
(Sand	27.020)
Alumina, Al_2O_3	24.730
Ferric oxide Fe_2O_3	2.720
Manganous oxide, MnO	trace
Lime, CaO	trace
Magnesia, MgO	0.404
Soda, Na_2O	1.138
Potash, K_2O	5.011
Titanium dioxide, TiO_2	1.380
Phosphorus pentoxide, P_2O_5	.240
Total	100.418

ETNA.—White and lavender colored clays are found in the iron ore pits of the Etna Furnace Company property, but in the workings examined, did not seem to be in as great quantity as at Oremont. The clay will be found similar in its properties to that at Oremont; it is white, yellow or purplish in color, very siliceous, and contains scattered fragments of chert, and iron ore; some has a grained or woody structure, and has the appearance of having resulted from the decomposition of rock *in situ*.

GRADY.—This place is located 6 miles east of Cedartown on the Seaboard Air Line Railroad. Clays occur in the iron ore pits of the Alabama and Georgia Iron Company. The clays are red, yellow, white and variegated, and occur in great quantities. The excavations here are extensive, covering 10 to 15 acres and the pits are from 20 to 60 feet in depth; clay occurs in all of the pits, but varies greatly in color, and different colors are intermingled.

White clay occurs in "horses," and in places and in small quantity seems to be quite pure, but the greater part is very siliceous and stained by iron. It could be mined with but little difficulty.

A sample of the variegated clay was tested in the laboratory. It showed fair plasticity, a low air shrinkage, 2.2 per cent., and a low tensile strength, not exceeding 10 or 15 pounds per square inch. It burned to a dense body, brown color, and without warping or cracking; it showed complete vitrification at cone 4, and above this temperature would probably blister and warp. These clays might be used in stoneware or terra cotta mixtures, because of their dense burning qualities, and low vitrifying points, but are not high-grade fire-clays. So far as the writer is aware no attempt, at all, has been made to use them commercially, and they are at present simply an obstacle in mining the iron ores.

The following analysis is given by Spencer[1] as being a type of the clay "horses" at Grady at the time of his examination:

Alumina	15.41
Ferric oxide	6.06
Potash	4.55
Soda	.34
Lime	.00
Magnesia	1.29
Titanic acid	1.35
Silica (combined)	20.10
Silica (free sand)	46.10
Water (combined)	4.70
Water (hygroscopic)	.20
Total	100.10

1. Geol. Surv. Ga., Paleozoic Group, p. 281.

The above analysis shows 12.24 per cent. of fluxing impurities, and it would be expected that such a clay would have a very low fusing point. White clays can be found with a much smaller percentage of iron, though none are kaolins or No. 1 fire-clays.

Cedartown.—Clays occur in great abundance in the iron mines west of Cedartown. They are varicolored, red, yellow white and purplish; the white are very siliceous, and are not uniform in color or composition. They may overlie or underlie the iron ore and have iron seams through them. None are high-grade fire-clays or kaolins. A sample of white and yellow clay from the Woodstock mine was tested in the laboratory with the following results:

It worked into a bright yellow plastic mass with an air shrinkage of 5 per cent.; its tensile strength was low, not exceeding 15 pounds per square inch. At cone 1, it was semi-vitreous and showed a fire shrinkage of 10.1 per cent.; it burned without warping or cracking to a dark chocolate color. There is a possibility of making vitrified brick from this clay. These clays might also be used for common building brick, though their low air dried strength would be a serious disadvantage. White and variegated clays occur in great abundance at the Ledbetter mines, 1¼ miles west of Cedartown.

Aragon.—There is a white clay shale on the property of F. M. Randall, about one mile north of Aragon on the Southern Railway. This seems to be an isolated deposit of Silurian shale, which has been altered by weathering agencies until it is semi-residual in character, yet preserves to some extent, its original structure. The clay lies in the top of a small knob or hill; and is probably limited in its area to this small hill. A small pit has been opened up, exposing 8 to 10 feet of clay with little or no overburden; the depth to which the clay extends has not been determined; chert and limestone are exposed on the slopes of the hill, and probably underlie the shale. The clay is white to lavender in color, very fine grained, and minutely jointed. Its white color is probably due to a leaching out of the iron originally in the shale. The sand or grit in the clay is in a very fine state and can scarcely be detected by the sense of touch; though it forms a much larger percentage of the clay than is apparent from a macroscopic examination.

Small amounts of this clay are being shipped for terra cotta and stoneware uses.

The following are physical tests upon a sample of the lighter colored clay:

Color	white when dry
Slaking	slakes very slowly
Hardness	semi-hard to soft
Texture	very fine grained
Plasticity	medium
Tensile strength	10 lbs. per sq. inch
Water required for mixing	37%
Air-shrinkage	2.7%
Cone 01—	
Color	white
Condition	soft, porous
Cone 4—	
Fire-shrinkage	12.9%
Color	dull gray
Condition	near vitrification
Absorption	4%
Cone 9—	
Fire-shrinkage	12.5%
Color	gray
Condition	complete vitrification
Fusing point	cone 27 and lower

This clay is very suitable for stoneware and terra cotta mixtures, because it burns to a light color and to a dense body at low temperatures, without warping or cracking. Its very low air dried strength is its greatest disadvantage. It is not a high grade fire-clay, being much inferior in refractoriness to the fire-clays of the Fall Line and to the bauxite clays.

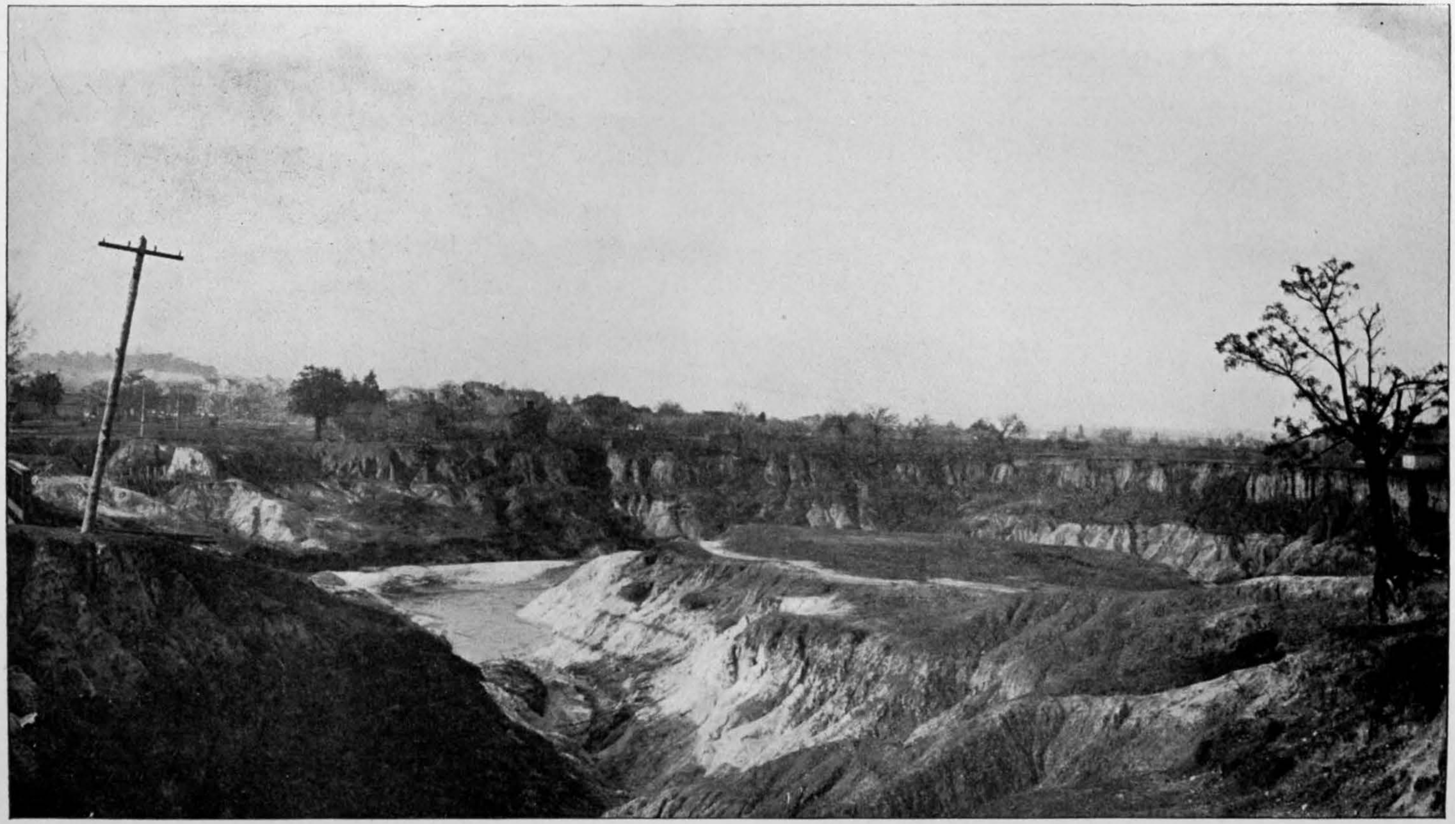
WALKER COUNTY

Residual cherty clays occur in large quantities derived from the decay of the Knox dolomite formation, and are used at one point for the manufacture of fire-brick. The cherty material containing a small amount of clay, is also used extensively for road material. Some low grade fire-clay is associated with the coal in the northwestern part of the county.

MISSION RIDGE.—The Mission Ridge Fire Brick Company operates a brick plant at this place, located on the Central of Georgia Railway, 8 miles south of Chattanooga, Tenn. The clay used, is a cherty, residual clay derived from the Knox dolomite. The main clay pit, located about ¼ mile west of the plant, shows a heterogeneous mass of chert and colored clays, with no sort of stratification or arrangement of material. The clays are white, drab, yellow and purplish and may be segregated in pockets; the chert varies from minute grains to angular fragments, 2 feet in length, and forms 80 to 90 per cent. of the material in the pit.

This coarse material or gannister does not itself contain sufficient clay to bind the mass together, and is hauled to the plant, and mixed with about one third of a residual plastic clay, occurring near the plant. The pit is about 30 feet deep; but weathering has probably extended to a depth of 75 or 100 feet in this vicinity. The colored plastic clay, mentioned above, is also a pocket of residual clay freer from chert than that in the main pit.

In the manufacture of the brick, the clays are first dried and then run through a dry pan crusher, and thence tempered in a wet pan. The clay is run through a stiff mud machine and repressed. The chert fragments are purposely left quite coarse. The brick have a very low air dried strength. According to the superintendent of the plant, the brick are burned to cone 2. In the process of burning the chert, particles are unaltered and are only loosely bound together by the burned clay, so that the brick are rather soft and friable.



General View of the Fall Line, Opposite Columbus, Georgia, Showing Recent Erosion.
The Upturned Crystalline Rocks are Overlain by the Cretaceous and Columbia Formations.

The refractory qualities of the brick are due to the chert and not to the clay.

A sample of the No. 1 fire clay was obtained for laboratory tests. The clay showed very poor plasticity, tensile strength not exceeding 15 pounds per square inch; air shrinkage, very low, 2.6 per cent. At cone 4, it showed a fire shrinkage of only 1 per cent. and was quite porous; at cone 12, it burned to a good hardness and showed a shrinkage of 5.5 per cent. At cone 30, 3,146° F., it was melted into a glass. It does not crack or warp in burning. The above tests were made upon a sample ground to pass a 40 mesh sieve; the coarse clay actually used, shows scarcely any air-shrinkage, and the shrinkage is less than the figures given above. The melting point of the mixture is lowered somewhat from the fact that the grains of chert are much finer, and chemical action between them and the fluxes takes place more readily.

The following is a chemical analysis of the No. 1 fire-clay used in the above tests:

Moisture at 100° C.	0.344
Loss on ignition	3.162
Silica	85.000
Alumina	9.722
Ferric oxide	1.352
Lime	trace
Magnesia	.000
Manganous oxide	trace
Sodium oxide	trace
Potassium oxide	.443
Titanium dioxide	.276
Sulphur	.000
Phosphorus pentoxide	.000
Total	100.299

OTHER LOCALITIES.—About one-half mile south of Mission Ridge there is a pit from which road material has been mined. There is less clay here, than in the pits of the Mission Ridge Brick Company, but the material might nevertheless, be utilized for refractory purposes; its fusing point will be slightly less than that of the chert. There are a number of other residual chert localities in the vicinity.

Residual chert and clay or gannister are abundant in the ridges of Knox dolomite near Lafayette. This material is used for roads and walks, but where plastic white clays occur in large quantity, it may be of some value for refractory purposes.

At the old bauxite mine near Harrisburg, on the Chattanooga Southern Railroad, in the southern part of Walker county, a lean siliceous clay occurs in great quantity, and may be of some value for refractory purposes.

Durham.—A sample of clay underlying the coal at the Durham Coal and Coke Company's mines on Lookout Mountain, was tested for its refractoriness. In other States the fire clays of the coal measures have proved to be of great economic value, but in Georgia these clays are of little promise on account of their small thickness, inaccessibility, and doubtful high refractoriness. The sample tested, was completely fused at cone 21, 2,822° F., and can hardly be considered a fire-clay at all. The sample probably did not represent the best clay, but on the whole, the clays do not seem to be of any considerable commercial importance. The clays are indurated or semi-indurated, and about 2 feet in thickness.

Thin beds of fire-clay underlie the coal seams of Pigeon Mountain, but they have not been investigated. Their inaccessibility and doubtful refractoriness make them of little importance.

CHATTOOGA COUNTY

Summerville.—White and pink soft, plastic, bauxitic clays occur in the Taylor bauxite mine near Summerville. An auger boring showed forty feet of clay. A sample tested in the laboratory was unfused at cone 33, 3,254° F., and has therefore, a very high refractoriness. It burns white to cream color, has a high fire shrinkage, and when burned alone cracked badly. The clay occurs in large quantity, is accessible, and should be of value for refractory purposes.

Cherty, residual clays similar to those being used at Mission Ridge, are found in the ridges of Knox dolomite, and may be of some value for refractory purposes. A large gravel pit, located about one mile south of Summerville on the Central of Georgia Railroad, contains pockets of yellow and white plastic clay, and may be of some value for fire-brick as well as for road material.

DADE COUNTY

No deposits of fire-clay or kaolin of much commercial importance have been developed in this county.

There are some interesting occurrences of halloysite, and there is a probability of cherty, residual clays similar to that at Kaolin, Alabama, being found near the base of the Fort Payne formation. Beds of "fire-clay" have been noted beneath the coal seams in the west side of Lookout Mountain and in Sand or Raccoon Mountain, but their refractory qualities have not been investigated, the beds rarely exceed two feet in thickness.

Rising Fawn.—A deposit of halloysite occurs about one mile south of Rising Fawn; the deposit lies near the base of the Fort Payne formation, (Carboniferous), well up in a hill on the west side of the railroad. A small amount of this material was mined 15 or 18 years ago, but it is not known to what use it was put. The halloysite is milky white, cream colored and yellow; the white variety is translucent on edges; it breaks with a smooth, conchoidal fracture and is too hard to be scratched with the finger nail. The specific gravity of the yellow variety is 2.26. The milk white variety is referred to by Dana[1] as glossecollite. I was unable to get any accurate

1. System of Mineralogy, 1893.

information about the thickness of the deposit, but it is probably not more than a foot or two. The halloysite is associated with a residual cherty clay, and was probably derived from kaolin, which itself resulted from the decomposition of the cherty limestone of the Fort Payne formation. The change might have been effected by acidulated waters, which altered the kaolin into a gelatinous or colloidal form.

A similar occurrence is also reported on the old Nesbit farm, southwest of Rising Fawn, and is said to have been mined about 20 years ago, and the product shipped to Philadelphia, where it was used as a food adulterant. On visiting the property, I was unable to find the deposit, and have no information as to its extent.

The following analysis given by Spencer,[1] is probably of the halloysite from this locality:

Alumina	30.76
Ferric oxide	.36
Silica	45.15
Water	23.55
Total	99.82

TRENTON.—There is a deposit of halloysite on the property of L. W. McLean, *lot 219, 10th district,* which seems to lie in the same geological position as that at Rising Fawn, viz., near the base of the Fort Payne formation, and immediately above the Devonian black shale. The only specimen that I was able to obtain, was deeply colored red by iron oxide. The following is a chemical analysis of this red variety:

Moisture at 100° C.	4.993
Loss on ignition	13.409
Silica	39.960
Alumina	33.802
Ferric oxide	7.995
Lime	.014
Magnesia	trace
Titanic oxide	.042
Total	100.215

1. Geol. Surv. Ga., Paleozoic Group, p. 212.

In view of the fact that similar deposits may be found in Georgia, the following tests[1] on the fire-clay which is at present being mined at Kaolin, Ala., about 4 miles from the Georgia-Alabama State line, are given. The tests on the first grade of fire-clay are:

"At 2,100° F. the clay burns white; at 2,300° F. it is white with a slight tinge of yellow, and at 2,350° F. it is the same with the total shrinkage amounting to only 4 per cent. Incipient fusion occurs at 2,400° F. and at cone 27 in the Deville furnace, the clay vitrified.

"The tensile strength is very low, not over 5 or 6 lbs. per square inch."

1. Alabama Geol. Surv. Bulletin No. 6, H Ries.

CHAPTER X

BUILDING BRICK, SEWER PIPE, ROOFING TILE, TERRA COTTA, AND COMMON POTTERY CLAYS

Clays suitable for use in the manufacture of any of the common clay wares, occur in abundance throughout the State, and are not, as in the case of the kaolins and fire-clays, confined to certain belts or geological horizons, but are widely distributed. The principal clay industry of the State is in the manufacture of common building brick; there are four sewer pipe and drain-tile plants; one roofing-tile plant, one terra cotta company and two companies manufacturing dry pressed brick. The common pottery industry is small, confined mainly to jugs, and will probably continue so, not from lack of suitable clays, but because of an unfavorable market. There is no reason why all of the pressed brick and ornamental building brick used in the State should not be manufactured in the State; there is also room for expansion in the manufacture of sewer pipe and drain-tile, and it is believed that excellent roofing-tile clays, other than the one deposit now worked, may be found.

In the following descriptions it is the aim of the writer to give attention to the geological distribution of clay deposits and to their probable commercial value, and detailed descriptions of individual plants are purposely omitted, as not being within the province of this report.

The descriptions are taken up by counties and localities;

some of the counties of the State are omitted, since their clay deposits are of such little or no economic importance.

APPLING COUNTY

There are no clay industries nor developed clay deposits in this county. The county is underlain entirely with the Altamaha formation, which consists of sand, sandstone, and sandy clays; the clays are fine grained, very plastic, and have high shrinkage. By mixing with the proper proportion of sand, they can be used for common building brick; they are not especially adaptable for brick purposes and their value will be in local use.

It is quite probable that excellent alluvial clays will be found along the Altamaha River, which forms the northern boundary of the county, but no prospecting has been done and the region is at present so remote from transportation lines, that clay, if found, would have little or no value.

BALDWIN COUNTY

Alluvial clays occur in the second bottom of the Oconee River, and are suitable for a variety of purposes. Red residual clays, derived from the decay of the crystalline rocks to the north of the Fall Line, occur in great thickness, but alone, are usually of poor quality for brick purposes on account of the high percentage of sand and undecomposed rock fragments, which they contain.

MILLEDGEVILLE.—Mr. J. W. McMillan manufactures common and repressed building brick, side walk paving blocks and fire-brick. The clay used is alluvium from the second bottom of the Oconee River, together with small amounts of residual clay occurring near the plant, and fire-clay from Carr's Station, 12 miles northeast of Milledgeville.

The alluvial clay is variable in thickness and texture. In the McMillan clay pit there may be seen as much as 10 to 12 feet of *brown,* sandy clay containing small iron oxide concretions; this upper clay is underlain by 3 or 4 up to 10 or 12 feet of *blue,* fine grained, very plastic clay; this clay is underlain by water bearing sand. The overburden amounts to practically nothing, and the clays are free from pebbles. The accumulation of water in the pits is the principal difficulty in mining; the clay is excavated from separate pits, the water being kept out of the pit in which work is being carried on, by clay partitions between it and other pits.

The brown clay may be as much as 75 per cent. sand and is considered too "short" for use alone, and is mixed with the more plastic *blue* clay. This blue clay is fine grained, very plastic and dense burning and has been used successfully for common earthenware. It is mixed with the sandy brown alluvium and a red residual clay for common building brick, and with the fire-clay from Carr's Station for fire-brick. A good grade of common building brick is made.

Stevens Brothers and Company own a pit a short distance north of the McMillan pit, from which clay is mined and shipped to their plant at Stevens Pottery for the manufacture of sewer pipe. The clay is similar to that in the McMillan pit.

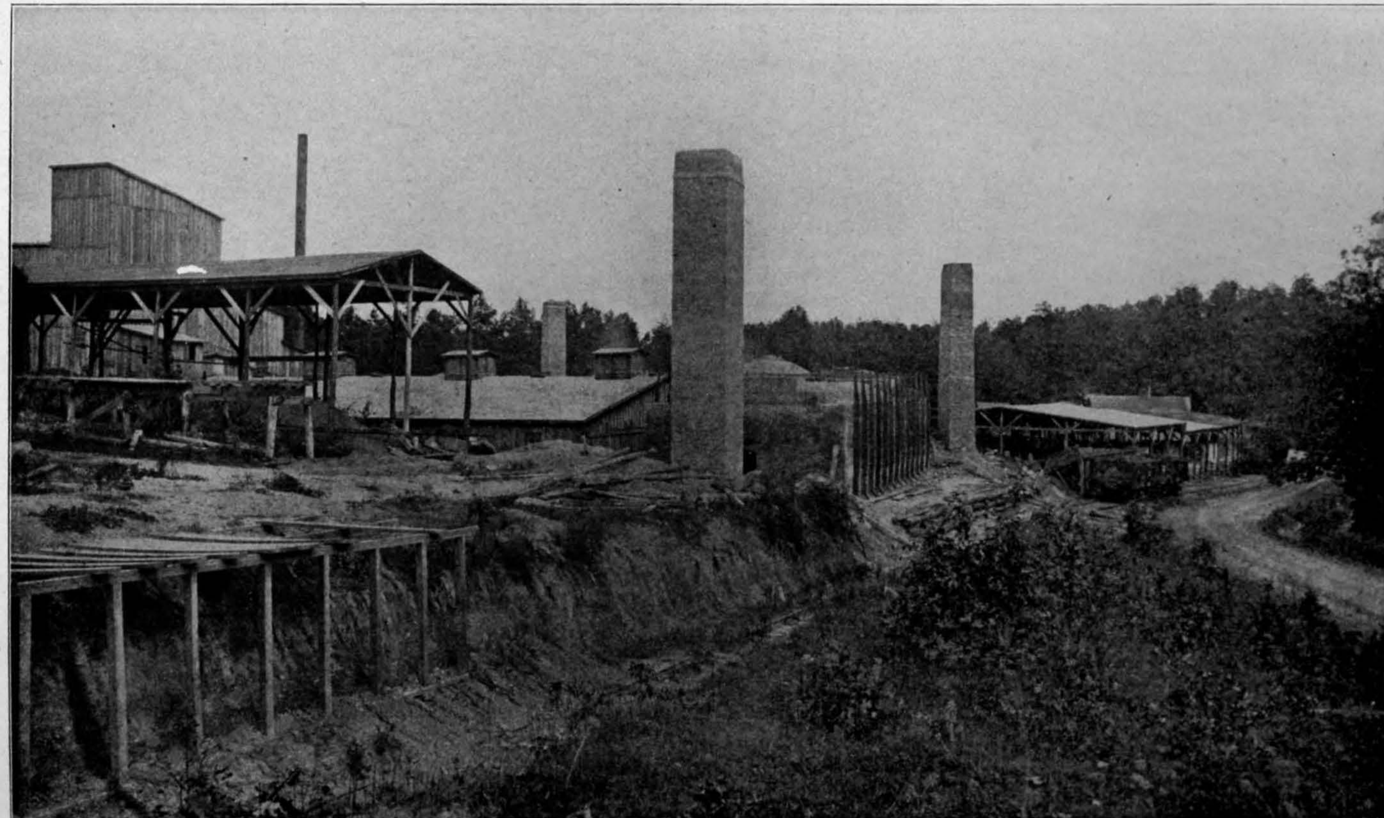
A sample of the better quality of red residual clay from a pit owned by J. W. McMillan gave the following results in the laboratory:

Coarse grained and sandy; when ground to pass a 40 mesh sieve, plasticity, poor; air shrinkage, average, 6.7 per cent.; tensile strength, 100 pounds per square inch.

Burning Tests

Cone	05	01	5
Fire-shrinkage	1.7%	4.4%	8.7%
Color	light red	red	dark red
Condition	soft	fair hardness	vitrified

The clay has good drying qualities and shows no tendency



PLANT OF THE MISSION RIDGE BRICK COMPANY, DODGE, WALKER COUNTY, GEORGIA.

to crack or warp in burning. The principal disadvantage is its poor plasticity, i. e., it is too "short" to work well.

BANKS COUNTY

No clays of value have been developed in Banks county, although brick clays suitable for local use may be found. The county lies within the Piedmont region and the rocks are hornblende and mica schists and granite gneisses. Plastic, alluvial clays occur along the small streams and may be of value for common building brick and pottery, but are not extensive deposits.

BARTOW COUNTY

The fire-clays of this county have been previously discussed and the shales will be considered in another chapter. The brick and pottery clays are alluvial and residual. Alluvial clays 5 to 15 feet in thickness occur in the flood plain of the Etowah River and are suitable for common building brick. Residual clays occur to great depths, but are generally quite sandy or contain fragments of undecomposed rocks, which greatly detract from their value for brick purposes. The residual clay of the Conasauga shale formation can in places be used for common building brick.

Cartersville.—The clay pit of the Cartersville Brick Company was examined. This company manufactures common building brick from the alluvium of the Etowah River. The clay is worked to a depth of 5 feet, is red and yellow in color, and the upper part is quite sandy and contains quartz pebbles. The brick made from this clay are quite porous, unless burned very hard, and are often cracked by the pebbles.

It is reported that 10 feet of bluish, more plastic clay underlies the upper 5 feet of sandy clay; it is probable that a better brick could be made by a mixture of the two clays.

The upper clay is not suitable for any other use than common building brick.

The following is an analysis[1] of the Etowah alluvium at Cartersville:

Silica	69.18
Alumina	15.43
Ferric oxide	5.83
Lime	0.00
Magnesia	0.71
Potash	1.83
Soda	0.15
Water (hygroscopic)	0.22
Water (combined)	6.61
Total	99.96

The following are tests on a sample of the siliceous, residual clay in the cut of the Louisville and Nashville Railroad about one-half mile north of Cartersville. The cut is about 30 feet deep; the residual material varies greatly in color, texture and composition. The clay is very *lean* or poorly plastic, has low air dried strength and air shrinkage of 4 per cent. It has good drying qualities, burns to a dark red and is vitrified at cone 5, but does not become viscous until above cone 12. On account of its poor plasticity and strength, it would be a rather inferior clay if used alone.

Residual clay derived from the Conasauga shale is being used for common brick at Adairsville.

Pottery Industry.—There are two small potteries located about 10 miles south of Cartersville. These potteries are small and manufacture common earthenware, as jugs, jars, crocks, flower pots, etc. The work is carried on in a primitive way and the business is purely local. Most of the ware is sold at the kiln and distributed through the surrounding country by peddlers. Most of the clay used by these potteries is obtained from the farm of R. M. Kerens, Paulding county, 6 miles southwest of Allatoona. The clay deposit is lo-

1. J. W. Spencer, Geol. Surv. Ga., Paleozoic Group, p. 287.

cated in the valley of Bolong Creek, near the head of the creek, and is colluvial or semi-alluvial in origin; it is bluish in color, fine grained, very plastic and 2½ to 3 feet in thickness.

A sample of this clay showed good plasticity and drying qualities; an air shrinkage of 7 per cent. and a tensile strength of 115 pounds per square inch. It burns to a dense body without warping or cracking, and is excellently adapted for common earthenware.

Deposits of bright red, highly ferruginous clay, containing well worn quartz pebbles, occur along the Etowah River. These deposits are probably Lafayette in age. They might be used for red, common building brick where not too sandy or pebbly.

BERRIEN COUNTY

This county is located in the Southern part of the State in what is known as the wire grass region. The land is generally flat and sandy. The surface formation is the Altamaha, which may be covered with a thin mantle of loose, brown or gray sand. The clays of the Altamaha formation are of very little importance and can hardly have more than a local value, and as far as is known, are adapted only for common building brick. Gray or mottled sandy clays were noted in the cuts of the Atlantic Coast Line Railroad in the northeastern part of the county near Enigma, and Heartsease.

BIBB COUNTY

The alluvial clay occurring in the second bottom of the Ocmulgee River is adapted for common and repressed building brick, sewer pipe and drain tile. The most extensive and broadest area of alluvium lies south of Macon, where the bottom or swamp land bordering the Ocmulgee may reach a width of two or three miles. Northward from Macon alluvial clay occurs, but it will be found restricted in area and probably coarser grained than the alluvium south.

The alluvial clay south of Macon, as is characteristic of other alluvial clays of all the larger streams of the State, is variable in thickness and texture. It varies from 2 to 12 or 14 feet in thickness with usually an average of 6 or 8 feet, a sufficient thickness for the economic use of the steam shovel. The clay near the surface is brown or yellow in color, usually quite sandy, while at greater depth it is lighter colored or bluish and quite plastic. The overburden is so small that it can be neglected; the clay is underlain by a fine water-bearing sand. There are no pebbles and no lime nodules; small yellow and black iron oxide accretions are abundant near the surface, but do not form any serious objection to the clay, only making black or fused splotches in the ware when it is not thoroughly disintegrated and pugged. The accretions are segregations of limonite from the clay, due to the weathering of the clay, and are usually surface phenomena; they are soft and easily crushed.

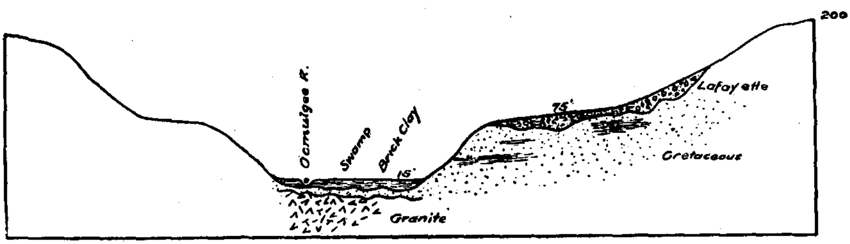


Fig. 10.—Section of the Ocmulgee River Valley at Macon.

The principal difficulties encountered in mining are in the drainage of the pits, and from roots of trees, unless the land has been cleared for some time, as the vegetation is very dense. The full thickness of the clay can not be mined on account of the bursting forth of springs from the underlying sand, and the danger of loss of tools and machinery by sinking into quick sand.

This alluvial clay is extensively used at Macon for the manufacture of common building brick, and has been the most successfully used brick clay in the State, and more common building brick are manufactured at Macon than at any other point in the State. In the manufacture of common building brick the surface, sandy or "short" clay is mixed with the lower or more plastic clay, and the full section in the pit utilized.

The clay is first run through pug mills and tempered, or may be dumped directly into the brick machine as it comes from the pit.

The clay has good drying qualities and will stand rapid firing. At the plant of the Bibb Brick Company, the green brick are dried in a Standard Dry Kiln in 36 hours, and large kilns have been burned in 4 days.

The Ocmulgee alluvium, mixed with fire clay, has been successfully used in the manufacture of sewer-pipe by the H. Stevens Sons Company, at Macon. The properties of the more plastic and better quality of the clays are not unfavorable for roofing-tile.

The following are laboratory tests on a sample of the alluvial clay from Macon. The sample was taken from the pit of the Bibb Brick Company, though it is in a general way representative of the clay at other localities:

Physical Tests

Water required	33%
Plasticity	good
Air-shrinkage	6.5%
Tensile strength (average of 7 briquettes)	150 lbs. per sq. inch
Cone 03—	
Fire-shrinkage	4.3%
Color	red
Absorption	10.7%
Cone 01—	—
Fire-shrinkage	4.6%
Color	red
Absorption	10.7%

Cone 4—

Fire-shrinkage	7.2%
Color	dark red
Condition	vitreous swelled

Cone 12—

Condition	vitreous, swelled slightly viscous

Tests made upon a hard burned brick from the plant of the Bibb Brick Company, showed 11.9 per cent. absorption after 48 hours immersion in water.

The clay will burn into a good durable brick with a uniform red color at a temperature as low as cone 03. It is not suitable for vitrified brick from the fact that the point at which vitrification takes place, about cone 4, and the point at which the clay begins to swell and blister, are too near together. The clay will, however, burn into a very dense body at about cone 1 or 2, making excellent brick for sidewalk paving.

The following is a chemical analysis of the Macon alluvial clay:

Moisture at 100° C	4.375
Loss on ignition	9.875
Silica SiO_2 (total)	52.860
(Sand	29.790)
Alumina, Al_2O_3	21.824
Ferric oxide, Fe_2O_3	6.400
Manganous oxide, MnO	.230
Lime, CaO	.370
Magnesia, MgO	.793
Soda, Na_2O	.358
Potash, K_2O	1.285
Titanium dioxide, TiO_2	1.196
Sulphur, S	.110
Total	99.676

The analysis is from a sample used for common building brick; the more plastic clay, that lying beneath the surface loam, will show a smaller percentage of sand and iron oxide.

BROOKS COUNTY

There are no clay industries in this county, and its clay resources are probably unimportant. Sandy clays, suitable for common building brick to meet a purely local demand, can probably be found.

The surface formations are the Altamaha formation, and the Columbia sand (Pleistocene). The clay of the Altamaha formation is covered by a thin mantle of gray Columbia sand, and where observed was very sandy and of poor quality.

BULLOCH COUNTY

There are no clay industries in this county, and its clay resources will probably be found comparatively unimportant, though clays might be found suitable for common building brick for a local use, when a superior quality of brick is not demanded. The county is entirely underlain by the Altamaha formation, composed of sand, sandstone and sandy clays. There are a very few natural exposures of clay. (For a general description of the clays of the Altamaha formation, see page 71.) The Ogeechee River forms the eastern boundary of the county, but it is a clear water stream and there are no alluvial clays along its course. There may be low or swampy areas in which the sandy clays of the Altamaha have become altered into sticky, plastic clays containing more or less organic matter.

BURKE COUNTY

The following are tests on a sample of red sandy clay from the property of Newton Palmer about 3 miles south of McBean. The material is the more argillaceous sand of the Claiborne red sand formation which is of widespread occurrence throughout the county.

The clay is a bright red, very sandy, has poor plasticity, and would be difficult to mold. Mixed with 33 per cent. of water, it showed an air shrinkage of 7 per cent.; its average tensile strength was low, 30 pounds per square inch. At cone 01, it burned to a very dark red, and showed a fire shrinkage of 4.8 per cent.; at cone 4 it burned to a very dark red, almost black, and was still rather friable, inasmuch as the sand in the clay was unaffected. The above tests were made upon a sample ground to pass a 40-mesh sieve, and should the clay be used on a commercial scale, both the air and fire shrinkage would be less than shown above.

The following is a chemical analysis of this clay:

Moisture at 100° C.	4.123
Loss on ignition	7.715
Silica, SiO_2	59.890
(Sand	37.210)
Alumina, Al_2O_3	19.823
Ferric oxide, Fe_2O_3	6.859
Lime, CaO	0.000
Magnesia, MgO	.176
Maganous oxide, MnO	.063
Soda, Na_2O	.277
Potash, K_2O	.086
Titanium dioxide, TiO_2	.830
Sulphur, S	.032
Phosphorous pentoxide, P_2O_5	.108
Total	99.982

This material might be used for common building brick though it would at best make an inferior product, on account of its poor plasticity and strength, and the high percentage of sand, which would cause the burned brick to be quite porous.

Sandy clays of the Altamaha formation were observed in the cut of the Central of Georgia Railway between Munnerlyn and Thomas, but do not give promise of being of much value.

CAMDEN COUNTY

The clays of this county are quite sandy and are either original sedimentary deposits occurring in the Altamaha formation or are swamp deposits of recent age. They are generally thin deposits and do not seem likely to have any other value than for common building brick, and are poorly adapted even for this purpose, though the scarcity of brick clays in this part of the State makes them worth consideration. The clays generally show a high air-shrinkage and a very low fire-shrinkage.

The following are tests on a sample of red, sandy clay from one mile south of Kingsland on the Seaboard Air Line Railroad on the property of James King.

The clay is quite sandy, 50 to 60 per cent quartz sand (estimate), but is fine grained and has a fair plasticity. Its air drying qualities are good, that is it can be rapidly dried without cracking; it required 23 per cent. of water for mixing; tensile strength 80 pounds per square inch; air shrinkage, 8 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*
07	...	salmon
03	1%	dark red
3	1%	dark red

This clay can be used for common building brick, though it will at best make only an inferior product. The best temperature at which to burn the brick would be about cone 03, below this temperature the brick would be too soft and porous, and above this temperature, the clay would likely burn to an ugly color and crack.

WOODBINE.—Laboratory tests were made on a sample of red clay from the Bedell property near Woodbine.

Physical Tests

The clay contained a high percentage of sand; required 22 per cent. of water for mixing; showed an air shrinkage of 7.6; the tensile strength was 100 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color.*	*Condition*
07	.....	light red	not steel hard
03	1.1%	dark red	" " "
4	1.1%	deep red	
12	1.0%	very dark	not vitrified

The clay would work in a stiff mud machine and a fair grade of common building brick could be made, but it is not likely to be suitable for any other purpose. A dense, impervious brick is not to be expected on account of the high sand content.

The following is a chemical analysis of a "red" clay from the Bedell property:

Moisture at 100° C.	5.694
Loss on ignition	5.094
Silica, SiO_2	70.278
(Sand	55.497)
Alumina, Al_2O_3	13.473
Ferric oxide, Fe_2O_3	3.638
Lime, CaO	.179
Magnesia, MgO	.446
Soda, Na_2O	.212
Potash, K_2O	.428
Titanium dioxide, TiO_2	.551
Sulphur, S	.440
Total	100.433

A small amount of brick has been burned near Pearl, on the Little Satilla River in the northern part of the county. The clay deposit at this place is small and the brick were inferior in quality.

CAMPBELL COUNTY

Alluvial clays occurring along the Chattahoochee River will be found suitable for common and repressed building brick and will be similar in their properties to those of the Chattahoochee, being used near Atlanta, and can be expected to occur in greater quantity. The clays, however, are not at present accessible to railway lines.

CARROLL COUNTY

Alluvial and colluvial clays may be found in the valleys of streams, and can be used for common building brick. The quantity of clay will not be found great except along the largest streams. The character of the clay along the Chattahoochee may be inferred from the description of the Sewell clay in Coweta county. The residual clays are of no value. A small brick yard has been operated at Whitesburg.

CHARLTON COUNTY

The surface of Charlton county is low, flat and swampy and covered by a mantle of fine, loose sand. There is little probability of good clays being found, though sandy clays occur which might supply a local demand for brick.

The following are the results of tests on a sample of clay from near Wainwright or Uptonville on the Atlantic Coast Line Railroad. The clay was very sandy and contained a small per cent. of organic matter. It showed an air shrinkage of 6.6 per cent., and an average tensile strength of 100 pounds per square inch; it stands rapid drying without cracking.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	0.4%	pale yellow	very porous
03	0.4%	pale red	soft, porous
01	0.4%	pale red	soft
2	0.8%	red	fair hardness
5	1.5%	dark red	semi-vitreous

A good red color was not developed, until cone 2, 2,138° F. was reached, although in practical burning, a red color would probably be developed at a lower temperature. With a clay containing such a large percentage of quartz sand, the best results could probably be obtained by burning at a higher temperature than is ordinarily reached in burning common building brick, if a hard brick is desired.

The county is underlain by the Altamaha formation which contains clay layers and sandy clays. The character of these clays may be seen in the bluffs of the St. Mary's River on the Florida side, at the Atlantic Coast Line Railroad bridge and at Calico Hill about one mile below. The material is similar to that being used at Waynesville and Odessa in Wayne county, Georgia.

CHATHAM COUNTY

The clays of Chatham county occur as pockets, of small extent, of Pleistocene age, or as layers of sandy clay in the Altamaha formation. The stiff, fine grained, bluish or drab plastic clays such as are found at Pooler are probably Pleistocene or recent deposits and will be found in the lower swamp land, while the low ridges or hills are composed of recent coastal sand, or sand and sandy clay of Pliocene age.

The county lies on the coast and the surface is low, flat and sandy and there are few natural exposures of its geological strata, and the extent of a clay deposit can be determined only by prospecting with an auger or by sinking shafts. The clay deposits are not of large extent, and they are inferior in quality and have serious objectionable properties even for common building brick, though their position adjacent to a city, Savannah, and the excellence of the market, make them of importance even though they may be unsatisfactory in many ways. There have been a number of small brick plants in operation at various times, but there is at present only two in the county, located at Pooler.

Brick clay is known to occur on the Sheldon tract, located between the Seaboard Air Line and Central of Georgia railways, 3½ miles west of Savannah. This is perhaps the most favorable deposit in the vicinity of Savannah. The clay reaches a thickness, as determined by auger boring, of 22 feet. It is confined to the lowland, and is probably a pocket of Pleistocene age resting upon older Pliocene sand and sandy clays, since the clay in the hill or ridge to the east is very sandy and differs from that in the lowland. The low land clay is very fine grained, bluish-black or drab in color, often contains a large percentage of fine sand, and near the surface has a dark color, due to organic matter. There is a thickness of 9 to 22 feet over 20 or 30 acres. The clay is free from pebbles and lime nodules, but contains scattered small crystals of gypsum, but the gypsum is not in sufficient quantity to cause any difficulty.

The following are the results of physical tests on a sample of clay from the Sheldon tract. The clay was bluish or drab in color, very fine grained, stiff, tenacious and very plastic.

Water required for mixing	23%
Plasticity	good
Air-shrinkage (average)	8.1%
Drying qualities	poor
Tensile strength (average)	221 lbs. per sq. inch

Burning Tests

Cone	*Fire-Shrinkage*	*Condition*
010	1.5%	soft, porous
08	2.0%	soft, porous
05	1.9%	absorption, 12%
03	3.1%	not steel hard
01	3.7%	not steel hard
2	3.7%	swelling
5	.....	cinder

The clay burns red; it shows a tendency to swell and crack if fired rapidly, and will not stand rapid drying. Both the drying and burning qualities could be improved by mixing with this clay a coarse sand or sandy clay. It can hardly be suited for any other purpose than common building brick.

The following is a chemical analysis of this clay:

Moisture at 100° C	3.220
Loss on ignition	6.549
Silica, SiO_2	64.240
(Sand	37.850)
Alumina, Al_2O_3	15.896
Ferric oxide, Fe_2O_3	6.630
Lime, CaO	.490
Magnesia, MgO	.619
Soda, Na_2O	.454
Potash, K_2O	1.199
Titanium dioxide, TiO_2	1.104
Sulphur trioxide, SO_3	.131
Total	100.532

POOLER.—The following are tests on a sample of brick clay from Pooler, 9 miles west of Savannah: The clay is very fine grained, stiff, and tenacious, and it is difficult to work in a stiff mud machine, and has to be very carefully dried to prevent cracking, unless a large percentage of sand is mixed with it. It showed an air shrinkage of 12.2 per cent., and a tensile strength of 123 pounds per square inch. The fire shrinkage is low; at cone 05 it showed .4 per cent., and at cone 01 only .4 per cent. It burns red and steel hard at cone 01. The chief fault of the clay is its poor drying qualities; this defect can be remedied by the addition of sand, though at the expense of the density and strength of the burned product.

OTHER LOCALITIES.—At the 4 mile-post on the Seaboard Air Line Railroad, west of Savannah, there is an exposure in a cut showing red sand and a gray or drab stiff clay layer of 3½ feet thick. This is a deposit different in origin from that on the Sheldon tract to the east. The clay is not likely to be found in large quantity.

On the Seaboard Air Line, 4½ miles west of Savannah, the following section was determined by an auger boring:

Black, sandy, surface clay........................	3½ feet
Bluish and yellow, sticky clay....................	5½ "
Quartz gravel and fine sand.......................	3 "

The clay contains small lime nodules and fragments of oyster shells. Brick were burned here a number of years ago.

A fine grained, stiff clay occurs on the O'Leary property, 6 miles west of Savannah. The writer has no information concerning its extent and properties, but it probably occurs in restricted areas in pockets.

Clay occurs near Wheat Hill on the Seaboard Air Line, 5 miles north of Savannah. At one point, a bluish, sticky clay was found to have a thickness of 10 feet, but it is not likely to be found in large quantity. This clay contains fragments of oyster shells.

CHATTAHOOCHEE COUNTY

Alluvial clays can be found along the Chattahoochee River and will probably have similar properties to those at Columbus and Omaha. Dark colored and black sandy clays occur in the Cretaceous formations but are at present of little value for clay products. There are no clay industries in the county. An exposure of Cretaceous clay, which might be suitable for common brick and other purposes, appears in the cuts of the Seaboard Air Line Railroad between the 16 and 17 mile-post.

CHATTOOGA COUNTY

The shales of this county will be considered in another part of this report. There are some brick and pottery clays of residual and colluvial origin, but these deposits are small and of but little value. The residual and colluvial clays are derived from the Knox dolomite and the Conasauga shales.

The following are tests on a sample of clay from the property of Robert McWhorter near Menlo. The clay occurs at the base of a ridge and is the washed residual clay of the Knox dolomite.

Fine grained, bluish-gray in color; air shrinkage, 8.5 per cent.; tensile strength about 100 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Condition*
03	5.3%	dense body
3	2.3%	swelled, warped, vitrified
12	.....	vesicular, warped

The clay might be used for common pottery, but it is not a fire-clay. It burns to a dull gray in color; the deposit is small.

CLARKE COUNTY

Alluvial clays occur along the Oconee and Middle Oconee Rivers, and when properly handled are capable of being manufactured into a good grade of common building brick. The county lies in the Piedmont Plateau, and is underlain mainly by a granite-gneiss which weathers into a red residual clay.

At the plant of the Georgia Brick Company, located on the Oconee River, 1 mile north of Athens, an alluvial clay is used for the manufacture of common building brick. The section in the pit showed 3 to 4 feet of yellow loamy clay underlain by 6 feet of bluish-white, more plastic clay. Beds of coarse, angular quartz gravel underlie, and pockets of sand are found in the clay. The clay is being worked in a stiff mud machine; it shows considerable shrinkage in drying and burning and burns to a light red color. The bottom of the pit is near the level of the river and water gives some difficulty in the mining of the clay.

A small brick plant is located on the Southern Railway, 1¼ miles north of Athens. The clay used is alluvial from a small stream entering the Oconee; the clay is 6 or 8 feet in thickness, fairly plastic, and can be used in a stiff mud machine. It is covered by a dense vegetation, and roots of trees give considerable difficulty in mining. The brick which have been made here are poor in quality, though this has been largely due to improper drying and burning, and the clay is capable of making a fair quality of common buliding brick.

A small brick yard has been operated 5 miles west of Athens on the Seaboard Air Line Railroad. The clay at this place is alluvial in origin and has a thickness of 5 or 6 feet. It is bluish-white, plastic, quite sandy and varies considerably in texture, and shows low shrinkage in drying and burning. The burned brick are badly laminated, porous, and light buff to pale red in color, depending upon the degree of burning and amount of surface clay mixed with the bluish-white clay. Some of the clay here would probably be suitable for common pottery.

CLAY COUNTY

The only clay of known value in this county is the alluvial Pleistocene clay of the "second bottom" of the Chattahoochee River. At the pit at the brick plant of the F. and C. Co-operative Company at Fort Gaines, the alluvial clay is about 6 feet in thickness, but shows variations in thickness and texture. The following are physical tests on a sample of this clay. It shows a good plasticity, an air shrinkage of 8.5 per cent. and can be dried rapidly without cracking; its average tensile strength was 185 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Condition*
01	3.9%	steel hard
5	6.7%	vitrified, warped
13	.....	swelled and vesicular

This clay is excellently adapted for common building brick; it burns red and to a good hardness at a low temperature, and can be easily worked in a stiff mud machine. It is of doubtful value for vitrified ware on account of its liability to warp at about the temperature of vitrification. The clay is free from pebbles or rock fragments and contains no lime.

CLAYTON COUNTY

Some alluvial or colluvial clays may be found along the streams of this county. The deposits, however, will be small. The residual clays are of little or no value.

COBB COUNTY

Alluvial clays suitable for common building brick may be found along the Chattahoochee and the larger streams of the county. Schists or metamorphosed shales, similar to the material being used at Bolton, in Fulton county, occur, but are poorly adapted for brick purposes, on account of their lack of plasticity and strength.

The following are tests on a sample of alluvial clay from the property of J. L. Dickey, 2½ miles from Oakwood, on the Southern Railway. Plasticity fair; drying qualities, good; air shrinkage, 6.4 per cent.; tensile strength, 108 pounds per square inch.

Burning Tests

Cone	Fire-Shrinkage	Color	Condition
05	0.3%	salmon	soft
03	2.9%	red	almost steel hard
3	2.9%	red	steel hard

The fire shrinkage is low, and there is no cracking or warping in burning. The clay is free from pebbles or rock fragments. It is well adapted for common building brick.

Chemical Analysis of Dickey Clay

Moisture at 100° C	1.743
Loss on ignition	9.271
Silica, SiO_2	54.502
(Sand	33.167)
Alumina, Al_2O_3	22.119
Ferric oxide, Fe_2O_3	8.309
Lime, CaO	.088
Magnesia, MgO	.424
Manganous oxide, MnO	.208
Soda, Na_2O	.620
Potash, K_2O	2.050
Titanium dioxide, TiO_2	1.134
Sulphur, S	.097
Total	100.565

COFFEE COUNTY

This county is entirely underlain by the Altamaha formation, consisting mainly of vari-colored sands and sandstones, with plastic clay layers. The topography of the county is low and rolling, and on account of a mantle of loose Columbia or coastal sand, there are few good natural exposures of the Altamaha strata; but sections may best be seen in the railroad and wagon road cuts. The clay layers of the formation are greenish or drab in color, very fine grained, plastic, and may reach 12 or 15 feet in thickness, though usually less. When mixed with sand, they may be used for common building brick, but are of little value alone on account of their tendency to crack and warp in drying and burning.

Alluvial clays will be found along the Ocmulgee River, which forms the northern boundary of the county, and are well adapted for common building brick and possibly also for drain tile and roofing tile, though they have not been tested for these latter purposes. The deposits are thin, however, probably not averaging more than 3 or 4 feet of workable clay, and will be found occurring in pockets.

A small brick plant is in operation at Barrow's Bluff on the Ocmulgee, 11 miles north of Broxton. A sample of the alluvial clay at this point was secured for tests in the laboratory.

Physical Tests on Clay From Barrow's Bluff

Yellow in color; fine grained; very plastic; water required for mixing, 35 per cent.; air shrinkage, 9.5 per cent.; tensile strength, average, 94 pounds per square inch.

Cone	*Fire-Shrinkage*	*Color*	*Condition*
04	1.7%	pale red	steel hard
1	3.7%	red	free from warping
4	4.2%	bright red	no warping or cracking

A small brick plant is in operation, 2 miles north of Douglas. The clay used belongs to the Altamaha formation, and in the pit, reaches a maximum thickness of 12 feet. It is inter-stratified with sand and contains sand pockets or lenses, and is overlain by red sand which may contain small quartz pebbles. The clay is mixed with sand and worked in a stiff mud machine. It is plastic, requires a high percentage of water for mixing, and has an air shrinkage of 14 per cent.; it has good strength, but can not be used alone on account of its tendency to crack and warp in drying and burning; when mixed with the proper proportion of sand and carefully burned, it can be made into a fair building brick of red color.

COLQUITT COUNTY

The clays of this county are confined to the Altamaha formation, which is, with the exception of the thin mantle of Columbia sand, the only geological formation exposed in the county. The clay occurs as thin layers in sands, and is fine grained and plastic and, as is with all of the Altamaha clays, has a very high air and fire shrinkage, but when mixed with the proper proportions of sand and thoroughly pugged can be made into a fair quality of common building brick.

Typical Altamaha clay is exposed in a cut of the Atlanta, Birmingham and Atlantic Railroad, 1½ miles southwest of Moultrie. There is 8 feet of stiff, plastic clay here, overlain by 4 feet of mottled clay-sand.

In the northeastern part of the county, exposures of mottled clay and sand were noted, which might be used for common building brick.

COLUMBIA COUNTY

Vitrified brick and sewer-pipe are manufactured by the Georgia Vitrified Brick and Clay Company at Campania, on the Georgia Railroad, 24 miles west of Augusta. This company has one of the largest and best equipped plants in the State. The clay used is a mixture of plastic Tertiary clays occurring near the plant, and non-plastic schists from Belair, in Richmond county; for vitrified brick, a mixture of about 80 per cent. of schist or ''shale'' and 20 per cent. of black and white plastic clay is used, and for sewer-pipe, 50 per cent. schist, 30 per cent. white clay, 20 per cent. black clay. The following tests and chemical analyses of these mixtures are given for comparative purposes:

Physical Tests

	I	II
Color (raw)	yellow	pale yellow
Water required	30%	35%

	I	II
Plasticity	poor	medium
Tensile strength	90 lbs. per sq. in.	126 lbs. per sq. in.
Air-shrinkage	3.6%	4.3%
Cone 1—		
Fire-shrinkage	3.4%	2.5%
Color	dark red	light red
Condition	not vitrified	steel hard
Absorption	7.9%	.....
Cone 4—		
Fire-shrinkage	10.2%	4.6%
Color	very dark red	purplish red
Condition	vitrified	not vitrified
Absorption	impervious	
Cone 13—		
Condition	viscous	slightly viscous

I Mixture for vitrified brick.
II Mixture for sewer-pipe.

The range between the points of vitrification and vicosity is sufficiently great to prevent any large loss in burning. The vitrification point of the sewer-pipe clay is high and in practice the pipe are not burned to vitrification.

Chemical Analyses

	I	II
Moisture at 100° C.		2.462
Loss on ignition	6.671	5.334
Silica SiO_2	54.496	56.920
Alumina, Al_2O_3	22.801	21.181
Ferric oxide, Fe_2O_3	6.554	7.676
Lime CaO	trace	.109
Magnesia, MgO	1.206	1.540
Manganous oxide, MnO	.041	.380
Sodium oxide, Na_2O	.262	.459
Potassium oxide, K_2O	1.404	1.807
Sulphur, S	.030	1.287
Titanium dioxide, TiO_2	1.250	.015
Total	100.262	100.678

Fuller's Earth, Grovetown.—A deposit of fuller's earth reported 10 to 12 feet in thickness, occurs near Grovetown, and may be of some value for brick purposes. It is a gray or drab in color, free from any high percentage of sand, thinly bedded, soft, and jointed; it breaks with a conchoidal fracture, and is smooth and unctous.

The following tests are given by Ladd[1]: Specific gravity,

1. Bulletin Ga. Geol. Surv. 6-A, p. 156.

1.3; air shrinkage, 16 per cent.; tensile strength, 144 pounds per square inch; shrinkage on burning, 4 per cent.

The clay requires a very high percentage of water for mixing, 60 to 75 per cent., and develops a fair plasticity; its air shrinkage is excessive, and on account of the high percentage of water absorbed, shows a tendency to crack in drying and burning; it burns to a buff color, and the burned brick are very light in weight. It might be worth while to make experiments on this material for dry pressed brick, since the fire shrinkage is not excessive, and there would be less liability of cracking in burning. A very attractive buff ornamental building brick might be made, should the objectionable burning properties of the clay be overcome.

COWETA COUNTY

Alluvial and colluvial clays suitable for common building brick, terra cotta, and stoneware, occur in this county. The colluvial clays are deposits found along small branches or creeks; they are the finer and purer clays of the residual deposits of the crystalline rocks, which have been washed from the hillsides and transported only short distances from their points of origin. They are bluish gray or light yellow in color, fine grained, plastic, and usually of very small extent and thickness.

The following physical and chemical tests will indicate the character of the alluvial clays along the Chattahoochee River. The sample on which the tests were made is from the property of Chas. T. Sewell, 2 miles above Whitesburg. The property is undeveloped and at the time of my visit it was difficult to secure a sample representative of the full thickness of the deposit.

The clay is plastic, shows an air shrinkage of 5.5 per cent.; tensile strength, 80 pounds per square inch. It can be dried rapidly without danger of cracking.

Burning Tests

Cone	Fire-Shrinkage	Color	Condition
05	1.2%	pale red	soft, porous
03	4.0%	red	steel hard
1	5.5%	red	steel hard
4	5.8%	very dark	slightly swelling
12	.....	black	vesicular

The clay should be excellently adapted for common building brick, but it is not suited for vitrified products.

Chemical Analysis of Sewell Clay

Moisture at 100° C	1.421
Loss on ignition	7.525
Silica, SiO_2	62.195
(Sand	45.000)
Alumina, Al_2O_3	20.007
Ferric oxide, Fe_2O_3	5.443
Lime, CaO	.376
Magnesia, MgO	.355
Manganous oxide, MnO	.010
Sodium oxide, Na_2O	.468
Potassium oxide, K_2O	1.621
Titanium dioxide, TiO_2	.946
Sulphur, S	.098
Total	100.465

There is a small deposit of colluvial clay near Turin, on the property of Chas. T. Moses, which has been used in terra cotta clay mixtures by the Atlanta Terra Cotta Company, Atlanta. The deposit lies in the valley of a small creek, is 3 to 4 feet in thickness and underlies only a small area. It is bluish to white in color and free from coarse sand, but passes gradually into the yellow and red residual clays of the hillside.

Other deposits, similar, can probably be found throughout the county.

The following are physical tests on the Moses clay:

Plasticity, very good; water required for mixing, 39 per cent.; air shrinkage, 9.3 per cent.; tensile strength, 86 pounds per square inch.

Burning Tests

Cone	Fire-Shrinkage	Color	Condition
4	8.8%	cream	absorption, 8%
7	10.4%	bluish-gray	steel hard
12	16.0%	bluish-gray	vitrified

Its fusing point lies near cone 27. On account of its good plasticity, fair strength, dense burning qualities and refractoriness, it is well suited for terra cotta and stoneware clay mixtures.

The following is a chemical analysis of this clay:

Moisture at 100°C	2.462
Loss on ignition	8.654
Silica, SiO_2	60.110
Alumina, Al_2O_3	24.256
Ferric oxide, Fe_2O_3	2.080
Lime, CaO	.110
Magnesia, MgO	trace
Manganous oxide, MnO	trace
Sodium oxide, Na_2O	.262
Potassium oxide, K_2O	1.647
Titanium dioxide, TiO_2	.754
Sulphur, S	.008
Phosphorous pentoxide, P_2O_5	trace
Total	100.343

CRAWFORD COUNTY

There are extensive areas of alluvial clays along Flint River, which forms the western boundary of Crawford county. These clays are yellow, brownish, or bluish in color and quite plastic; the yellow and brownish clays lie near the surface and are underlain by bluish, finer grained and more plastic clays; they will vary in thickness, but will probably show an average of 6 feet. They are undeveloped, but give promise of being suitable for building brick, drain tile and sewer pipe.

The following are tests on samples of alluvial clay from the property of S. H. Phelan, 8 miles southwest of Roberta and about two miles west of the Southern Railway. The surface clay is yellow or brown in color, sandy and contains small black accretions of iron oxide, and is underlain by a bluish, fine-grained, very plastic clay.

Physical Tests of Brown Clay

Fair plasticity; air-shrinkage, 7.2 per cent.; tensile strength, 132 pounds per square inch.

CLAY PIT OF THE CHEROKEE BRICK COMPANY, MACON, BIBB COUNTY, GEORGIA.

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	3.7%	red	fair hardness
03	4.5%	red	steel hard
5	7.8%	almost black	vitrified
13	.....		vesicular

The clay can be rapidly air dried and burned without danger of cracking or warping.

Physical Tests on Blue Plastic Clay

Very plastic; air-shrinkage, 10.1 per cent.; tensile strength, 130 pounds per square inch.

Cone	*Fire-Shrinkage*	*Color*	*Condition*
07	1.4%	pale red	fair hardness
3	14.2%	bright red	steel hard, slight checking

This clay has a higher air shrinkage than the brown clay and more care would have to be exercised in its drying and burning; it burns to a denser body than the brown clay, but has a greater tendency to crack and warp.

Chemical Analyses

	I	II
Moisture at 100° C.	1.289	2.900
Loss on ignition	10.512	7.390
Silica (total) SiO_2	55.608	59.084
(Sand	25.688	40.538)
Alumina, Al_2O_3	23.466	20.313
Ferric oxide, Fe_2O_3	5.590	5.593
Lime, CaO	trace	.578
Magnesia, MgO	.353	.409
Sodium oxide, Na_2O	.470	.487
Potassium oxide, K_2O	1.162	2.109
Titanium dioxide	1.377	.854
Sulphur, S	.004	.072
Total	99.831	99.789

I Blue clay.
II Brown clay.

The clays give promise of being excellently adapted for common building brick, and by mixing a small percentage of the white clays of the Cretaceous formation, which occurs nearby, offer possibilities for sewer pipe, though a thoroughly vitrified body could hardly be expected. It is also suited for drain tile, but not for vitrified brick. For common building brick, the best results could be obtained by using the whole thickness of the clay.

The alluvial clay of Flint River is accessible to the Central of Georgia Railway near Everett. It can hardly differ greatly from the Phelan clay described above. There are small deposits of swamp clays, used in the manufacture of common pottery, in the eastern part of the county.

CRISP COUNTY

The clays of this county are comparatively unimportant. Sandy clays could possibly be found which could be used for supplying a local demand for common building brick. Greenish sandy clays of the Altamaha formation were observed in a cut of the Georgia Southern and Florida Railroad between Wenona and Arabi.

DECATUR COUNTY

Bluish or greenish, sticky, sandy clays of the Altamaha formation occur in great thickness in the eastern and southern parts of the county, and may be used for common building brick. Alluvial and swamp deposits occur along Flint River, though the swamp deposits can hardly be expected to be of any considerable thickness or underlie any large area. The Altamaha clays, such as occur in the vicinity of Climax and southward from Bainbridge along the Georgia Southern and Florida Railroad, while having some very objectionable properties, can, when properly handled, be made into a fair grade of common building brick.

The following geological section[1] made along the Atlantic

1. This locality has been visited by Dr. T. Wayland Vaughan, of the U. S. Geological Survey, and is described, together with tests on the clay, in Professional Paper No. 11, p. 91, U. S. Geological Survey.

Coast Line Railroad west of Climax, will illustrate the occurrence of the Altamaha[1] clays:

		Feet
1	Yellow, massive sand and soil	8
2	Mottled or calico sand	8
3	Purplish and red crossbedded sand, and thin limonite crusts	15
4	Mottled or calico clay layer	3 to 6
5	Crossbedded, red and purplish sand	12
6	Purplish and red sand, and laminated bluish clay layers	15
7	Grayish, stratified sandy clays and greenish, sticky clay layers	15
8	Greenish or drab, very sandy clay	12

At Mashburn Hill, 4 miles north of Climax, there are 60 feet of greenish, sticky clays, variable in the amount of sand and containing scattered small, flat, white siliceous nodules.

A great thickness of sticky, tenacious sandy clay occurs along the public road leading east from the station at Attapulgus.

A good exposure of the Altamaha clay may be seen in a cut Georgia Southern and Florida Railroad near where it is crossed by the Atlantic Coast Line.

Occurrences of the Altamaha clay and sand are numerous; the clays are generally quite sandy, may be of variable thickness, and are sometimes nearly white in color. The following physical and chemical tests will indicate the character of the clays.

Physical Tests on a Clay From a Cut of the Atlantic Coast Line Railroad, One Mile West of Climax

Plasticity, good; very fine grained; water required for mixing from 40 to 55 per cent.; tensile strength, variable, 264 pounds per square inch; air shrinkage, variable, average, 11.5 per cent.; drying qualities, very poor.

Burning Tests

Cone	Fire-Shrinkage	Color	Condition
05	2.2%	light red	steel hard
03	1.9%	light red	steel hard
1	0.9%	red	swelled
4	.....	black	blistered and vesicular

1. The lowermost greenish or drab sandy clay of the section may be found to be of Oligocene age.

The clay can not be dried or burned rapidly, without its cracking, warping or swelling. It will show a tendency to laminate and black core. The black coring is due to the incipient vitrification of the exterior of the brick preventing the oxidation of the interior so that the iron is in a ferrous condition. The black cores will burn red when the brick is broken and again burned under oxidizing conditions. The only way in which the clay can be used successfully, is by mixing sand with it, and thoroughly pugging; but an impervious brick can not be obtained at any temperature. The brick show no appreciable scumming.

Physical Tests on Clay From Mashburn Hill

This clay is very fine grained, but contains more sand than the Climax clay; plasticity, medium; drying qualities, poor; tensile strength, 192 pounds per square inch; air shrinkage, 12.3 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
03	2.4%	brown-red	not steel hard
01	1.2%	dark red	swelling
4	1.9%	dark red	semi-vitreous, swelled
11	.....	black	vesicular

Chemical Analysis of Mashburn Hill Clay.

Moisture at 100° C	5.600
Loss on ignition	10.106
Silica, SiO_2	55.560
Alumina, Al_2O_3	19.076
Ferric oxide, Fe_2O_3	7.140
Manganous oxide, MnO	.044
Lime, CaO	.000
Magnesia, MgO	.706
Soda, Na_2O	.349
Potash, K_2O	.864
Titanium dioxide, TiO_2	1.104
Sulphur, S	trace
Total	100.549
Quartz sand	23.336
Combined silica	32.194

The above analysis suggests that the clay base is in the nature of a fuller's earth, and such being the case, the high percentage of water absorbed and retained by the Altamaha clays is explained.

Physical Tests on Brick Clay From Attapulgus

Plasticity, medium; air shrinkage, 13.2 per cent.; tensile strength, 279 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
07	0.8%	pale red	fair brick hardness but very porous
03	3.1%	red	not steel hard
3	3.1%	dark red	steel hard
12	5.2%	purplish red	not vitrified

The air shrinkage is high, and the burned product has low strength. The clay could be used for common building brick, though a first class brick is hardly to be expected.

The following physical tests on the fuller's earth mined at Attapulgus are interesting, though the fuller's earth itself is of no value for clay products. A sample ground to pass a 40 mesh sieve, showed a low plasticity and required 92.6 per cent. of water for mixing; its average air shrinkage was 7 per cent.; it showed a maximum tensile strength of 50 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
04	23.2%	light buff	brittle
5	23.2%	buff	slightly warped not vitrified
12	......		fused to a greenish glass

Chemical Analysis of Attapulgus Fuller's Earth

Moisture at 100° C.	8.970
Loss on ignition	10.910
Silica	54.110
Alumina	13.028
Ferric oxide	4.080
Manganous oxide	.110
Lime	.900
Magnesia	5.860
Sodium oxide	.183
Potassium oxide	.486

Titanium dioxide	1.012
Sulphur	.000
Phosphorous pentoxide	.000
Total	99.649

It will be observed that the water required for mixing is three or four times that required by ordinary clays, yet the air-shrinkage is low. The explanation of this phenomenon is that the particles of crushed earth were coarse and that the water held between the pore space formed by these coarse particles and lost in drying, could consequently cause no great lessening of volume, and that the minute pore spaces of the individual particles, themselves, retained most of the water from these spaces, and would not cause any contraction, since the earth was sufficiently hard to prevent its microscopic structure from being destroyed in the mixing process. Should the earth be passed through an 80 or 100 mesh sieve, its air shrinkage would be much greater. In burning, the microscopic pores are closed by fusion of the earth and a very high fire-shrinkage results.

The earth burns to a light color, though as shown by the analysis, it contains 4.08 per cent. of Fe_2O_3; the coloring effect of the iron is probably neutralized by the magnesia.

The following are tests on a sample of alluvial clay from the L. F. Patterson brick yard, ½ mile north of Bainbridge: Plasticity, good; fine grained; tensile strength, 125 pounds per square inch; air shrinkage, 8.9 per cent.

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	3.9%	pale red	good brick hardness
03	4.3%	red	steel hard
01	4.3%	dark red	very dense body
4	4.3%	dark red	almost vitrified

This clay, when mixed with the surface sandy loam, has good drying qualities and can be worked in a stiff mud machine; it burns into a dark red brick of good density, and shows no *scumming* after burning. The clay at this point is about 9 feet thick, yellowish or bluish in color, and free from pebbles or coarse rock fragments. Roots from trees and flooding of the pits from back water from the river are serious obstacles in the mining of the clay. The clay is capable of making a good quality of common building brick.

Some deposits of clay occur in low swampy places, not river swamps, south of Bainbridge, and are probably worked over Altamaha clays. The clays are bluish or black in color from organic matter, very plastic, have a high air-shrinkage and would probably show poor drying and burning qualities.

DeKALB COUNTY

Alluvial and colluvial clays occur along the streams, but inasmuch as there is no very large stream in the county, the deposits are of small extent. The clays are generally unfit for any other purpose than common building brick. The red residual clays if used alone, are almost valueless for brick purposes, but might be mixed with more plastic clays, when they do not contain coarse rock fragments. Common building brick are being manufactured by the South River Brick Company, Atlanta, near Constitution, from the alluvium of South River.

DODGE COUNTY

Plastic alluvial clays suitable for common building brick may be found in the bottoms along the Ocmulgee River. No prospecting or development has been done, and nothing is known concerning the clay; the deposits are most likely to be of small thickness. Mottled sandy clays of the Altamaha formation were observed in the cuts of the Southern Railway, southwest from Eastman.

DOUGHERTY COUNTY

Clays suitable for common building brick occur on the first and second terraces along Flint River. There are two companies manufacturing common building brick at Albany, the Cruger-Pace Brick Company and the Albany Brick Company. The alluvial clay on the property of Cruger-Pace Brick Company is from 3 to 10 feet thick, and occurs in pockets. The section in the pit is: 1, brown loam and sand, 2, bluish, stiff clay, 3, stiff, tenacious clay, containing limestone fragments. The stiff plastic clay and the brown loamy sand are mixed for common building brick. The clay containing the limestone fragments is not used, but could be if the limestone were crushed sufficiently fine. The blue plastic clay alone will not stand rapid drying or firing without cracking, and would be difficult to work through a stiff mud machine. It burns to a buff color, and might be used for dry pressed brick. The alluvial clays along Flint River will generally be found quite sandy and likely to occur in pockets.

On the property of J. W. Walters, about 1½ miles southwest of Albany, there are pockets of red and yellow and bluish or drab clays, 3 to 6 feet in thickness. Two samples from this property were tested in the laboratory, a red and yellow stiff plastic clay occurring in depressions in an open cultivated field, and a drab or black clay, occurring in a wooded and swampy area, and containing more or less organic matter.

Physical Tests

	I	II
Water required	22%	30%
Plasticity	good	good
Air-shrinkage	8.7%	8.0%
Tensile strength	116 lbs. per sq. in.	151 lbs. per sq. in.
Texture	fine grained, sandy	fine grained
Cone 07—		
Fire-shrinkage	0.3%	
Color	very pale red	
Cone 05—		
Fire-shrinkage	....	2.6%
Color	....	buff
Condition	....	steel hard
Cone 03—		
Fire-shrinkage	1.1%	
Color	light red	
Condition	soft, porous	

Cretaceous Sand and Clay, Railroad Cut 2 Miles North of Byron, Houston County, Georgia.

	I	II
Cone 01—		
Fire-shrinkage		5.1%
Color		light buff
Cone 1—		....
Fire-shrinkage		5.1%
Color		buff
Condition		cracked
Cone 4—		
Fire-shrinkage	5.2%	5.8%
Color	red	almost red
Cone 12—		
Fire-shrinkage	2.2%	
Color	very dark red	leathery buff
Condition	not vitrified	cracked badly, not v'tf'd

I Field clay.
II Swamp clay.

On account of the high sand content in the field clay, it will not produce good brick at low temperatures. The clay is not likely to be suited for any other purpose than common building brick. When containing a high percentage of sand, as in the sample tested, its drying qualities are fair and it could probably be successfully used in a stiff mud machine. The swamp clay shows a smaller percentage of sand, and it would probably give trouble in drying if used alone. It burns to a denser body than the field clay and to a lighter color; the color to which it burns will be largely governed by kiln conditions. It offers a possibility for dry press building brick. For common building brick, the best results could perhaps, be obtained by a mixture of the field and swamp clay. Neither of the clays would be suitable for vitrified brick or sewer pipe.

Deposits of similar clays could probably be found at other points along, and on both sides of Flint River, in Dougherty county.

Chemical Analyses of Clays from near Albany

	I	II	III	IV
Moisture at 100° C.	3.446	6.428	0.94	1.04
Loss on ignition	5.870	8.640	10.73	10.96
Silica, SiO_2	69.876	58.380	57.80	58.00
(Sand	49.892	28.749	.....	.....)
Alumina, Al_2O_3	15.071	21.152	23.12	23.14
Ferric oxide, Fe_2O_3	4.306	3.360	5.28	5.12

Lime, CaO	.329	.530	.06	.11
Magnesia, MgO	.086	.140	.20	.18
Soda, Na_2O	.304	.349	.30	.34
Potash, K_2O	.333	.259	.47	.60
Titanium dioxide, TiO_2	.796	.828	1.01	.84
Total	100.417	100.066	99.91	100.33

I Field clay, J. W. Walters.
II Swamp clay, J. W. Walters.
III Clay from R. H. Warren, lot 318,1st district.
IV Clay from R. H. Warren, locality as above.

EFFINGHAM COUNTY

Sandy clays are distributed through the county and might be used for common building brick, though upon the whole, the clays are of poor quality even for this purpose.

A point of considerable historical interest, is old Ebenezer, located on the Savannah River; since probably the first brick manufactured in Georgia were made at this place. A colony of Salzburgers settled here in 1733 and in 1769 built a brick church, the bricks being made at this locality, which is at the present time in a state of tolerable preservation and is still used for religious services. The brick are a dark red, a little larger than standard size, and quite sandy and porous. A test on a half brick showed an absorption of 16.6 per cent.

The clay at this place which is said to have been used for the brick in the church, is probably of Pliocene age and is a greenish or drab, very fine grained, plastic clay inter-stratified with red and yellow sand. The deposit lies 30 or 40 feet above the Savannah River and is underlain by a greenish and drab, sticky, sandy clay and sands. The material here could be made into a fair grade of common building brick, but the commercial value of the deposit is seriously lessened because of its distance from a railway line.

The following are tests on a sample of the top clay at Ebenezer; the material is a mixture of fine grained clay and ferruginous quartz sand, and tests on different samples will show variations because of differences in the sand content.

The sample tested required 40 per cent. of water to develop its best plasticity; it showed a tensile strength of 91 pounds per square inch, and an air shrinkage of 9.3 per cent.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	1.5%	pale red	absorption 16%
01	1.2%	red	absorption 15%
4	3.4%	dark red	not vitrified

With the proper proportion of ferruginous sand, the clay will have good drying qualities and burn to a good red color.

Chemical Analysis of Ebenezer Clay

Moisture at 100° C.	1.776
Loss on Ignition	6.921
Silica, SiO_2	63.400
(Sand	40.475)
Alumina, Al_2O_3	19.614
Ferric oxide, Fe_2O_3	6.422
Lime, CaO	none
Soda, Na_2O	.087
Potash, K_2O	.821
Titanium dioxide, TiO_2	1.104
Total	100.145

The following are tests on two samples of clay from Old Purisburg on the Savannah River, made by the Richardson-Lovejoy Engineering Company of Columbus, Ohio, and furnished the writer by Mr. Wayne Cunningham of Savannah.

Sample No. 1, a mixture of light colored and red clay, and coarse sand.

Air-shrinkage	*Cone*	*Fire-shrinkage*	*Total shrinkage*
9.8%	07	1.3%	11.1%
10.0%	04	2.2%	12.2%
9.0%	02	4.5%	13.5%
9.5%	1	4.5%	14. %
9.8%	3	4.9%	14.7%
10.0%	5	5.0%	15.0%
9.7%	7	5.1%	14.8%

The clay burns to a light red.

Sample No. 2, a light gray, sticky, shaley clay.

Air-shrinkage	Cone	Fire-shrinkage	Total shrinkage
10.5%	07	1.2%	11.7%
9.2%	04	5.8%	15. %
9.2%	02	6.3%	15.5%
11.4%	1	6.1%	17.5%
10.6%	3	6.6%	17.2%
10.3%	5	6.8%	17.1%
10.3%	7	7.1%	17.4%

The tests do not indicate that the clays are at all suited for any other purpose than common building brick.

These clays are probably Pliocene deposits and in the same geological position as the clays at Ebenezer.

FLOYD COUNTY

Alluvial clays suitable for common and dry press building brick, occur along the Etowah, Oostanaula, and Coosa rivers. The residual clays are comparatively of little value. The shales will be discussed in another chapter.

Alluvial clays along the Etowah may reach a thickness of 15 feet, and usually consist of brown or yellow very sandy clays at the surface, underlain by bluish, fine grained more plastic clays. Common and pressed brick are being manufactured at Rome, by the Morrison-Trammel Brick Company and the Rome Brick Company. The alluvial clays of this county are not fire-clays and are of doubtful value for any other use than building brick.

The following is a section of the Etowah River alluvium at the plant of the Morrison-Trammel Brick Company.

		Feet
1	Soil and yellow, sandy micaceous clay	5
2	Bluish, plastic clay	9
3	Yellow sand	4
4	Black sand	3

For common building brick, the clays are mixed about ⅓ yellow sandy clay and ⅔ plastic clays. Some attempt has been made to manufacture drain tile from the bluish plastic clay, but with little success. The clay pits have a natural underground drainage.

The following are tests on a sample of the blue, plastic clay from this place: The clay is fine grained, plastic, and contains a small amount of organic matter which gives it its dark color. It has a high air dried strength, 221 pounds per square inch; its air shrinkage is 8.2 per cent. At cone 5, it burned to a very pale red, and showed a fire-shrinkage of 2.5 per cent; at cone 4, it burned to a light yellow-buff, with a fire-shrinkage of 5.5 per cent; it was steel hard, but not vitrified. This clay could probably be used successfully for dry press brick; the color to which it would burn, from light red to buff, would be largely governed by kiln conditions. This clay is less fusible than the yellow surface clay, but it is not a fire-clay. Used alone, it is of doubtful value for vitrified products, but there is a possibility of its being used in connection with the extensive Cambrain shales near here for vitrified brick.

The Rome Brick Company operates a brick plant a short distance east of Rome. The clays used are the alluvial clays of the Etowah River, a red silty clay of Lafayette age, and shale. A bluish, plastic, sandy clay containing quartz pebbles, and reported 7 feet in thickness, is used in the manufacture of buff brick; for common building brick, a mixture of red Lafayette clay and the brown sandy alluvium 1 to 4 feet in thickness, was being used at the time of my visit at the plant. The Lafayette clay is a bright red, very sandy and contains scattered quartz pebbles, and is on the whole poorly adapted for brick.

W. T. Cheney Property.—The following tests on two samples of alluvial clay from the property of W. T. Cheney, east of Rome, will assist in giving some idea of the character of the alluvial clay of the Etowah:

Sample No. 1 was a fine grained clay containing a high percentage of sand, but having good plasticity; it is almost black in color, due to organic matter. Its air shrinkage was

8 per cent., and tensile strength high, averaging 215 pounds per square inch.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	0.7%	salmon	fair density
01	0.7%	red	almost steel hard
4	1.4%	red	steel hard but not vitrified.

The air shrinkage is low and the clay does not crack or warp in burning.

Sample No. 2 was a yellow, very sandy clay, surface alluvium, and less plastic than the dark colored clay. It showed and air shrinkage of 3.9 per cent. and a tensile strength of 54 pounds per square inch.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
07	0. %	salmon	very soft
05	0.3%	salmon	soft
3	2. %	dark red	steel hard

Chemical Analyses of Etowah Alluvial Clays near Rome

	I	II	III	IV
Moisture at 100° C.	0.80	1.72	0.25	0.20
Loss on ignition	3.89	6.60	7.35	4.70
Silica, SiO_2	79.42	72.65	67.80	77.60
(Sand	67.77	51.74	50.80	63.30)
Aluminum, Al_2O_3	9.18	11.92	13.82	10.90
Ferric oxide, Fe_2O_3	4.25	4.25	5.74	2.25
Lime, CaO	trace	0.34	0.00	0.00
Magnesia, MgO	0.35	0.43	0.81	0.63
Soda, Na_2O	0.20	0.32	0.55	0.32
Potash, K_2O	0.72	0.80	2.00	1.83
Titanium dioxide, TiO_2	1.29	1.15	1.67	1.98
Total	100.10	100.18	99.99	100.41

I Yellow sandy alluvium.
II Dark colored alluvium.
III Surface alluvium, Spencer, Paleozoic Group, Ga. p. 287.
IV Lower alluvium, Spencer, Paleozoic Group, Ga. p. 288.

The alluvial clay of the Oostanaula River will perhaps be found generally sandier and less plastic than that of the Etowah. Common building brick are being made at Rome from the alluvium of the Oostanaula near its junction with the Etowah; the brick are quite soft and porous and are of poor quality.

Small pockets of plastic clays occur throughout the areas underlain by the Conasauga shale formation and are colluvial in origin. They result from the residual clays being washed into small valleys or depressions. These clays are plastic, "sticky," and fine grained; they have a high shrinkage, a very high tensile strength and burn to a dense body.

FRANKLIN COUNTY

Brick plants are, or have been in the past, located at Canon, Royston, Lavonia and Carnesville. These plants are small, unfavorably located as to good markets, and are operated only a part of the year. Small deposits of clay along streams are used. The following are tests on the clay being used by Bowers Brothers at their plant at Canon.

The clay is sandy and micaceous, and has good brick clay plasticity; tensile strength, 180 pounds per square inch; air shrinkage 7.2 per cent. It has good drying qualities.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
03	3.2%	light red	soft
01	3.9%	light red	soft
3	5.0%	dark red	steel hard

The clay does not burn to a dense body at low temperatures and unless thoroughly pugged, laminates badly when worked in a stiff mud machine.

Chemical Analysis of Brick Clay from Canon

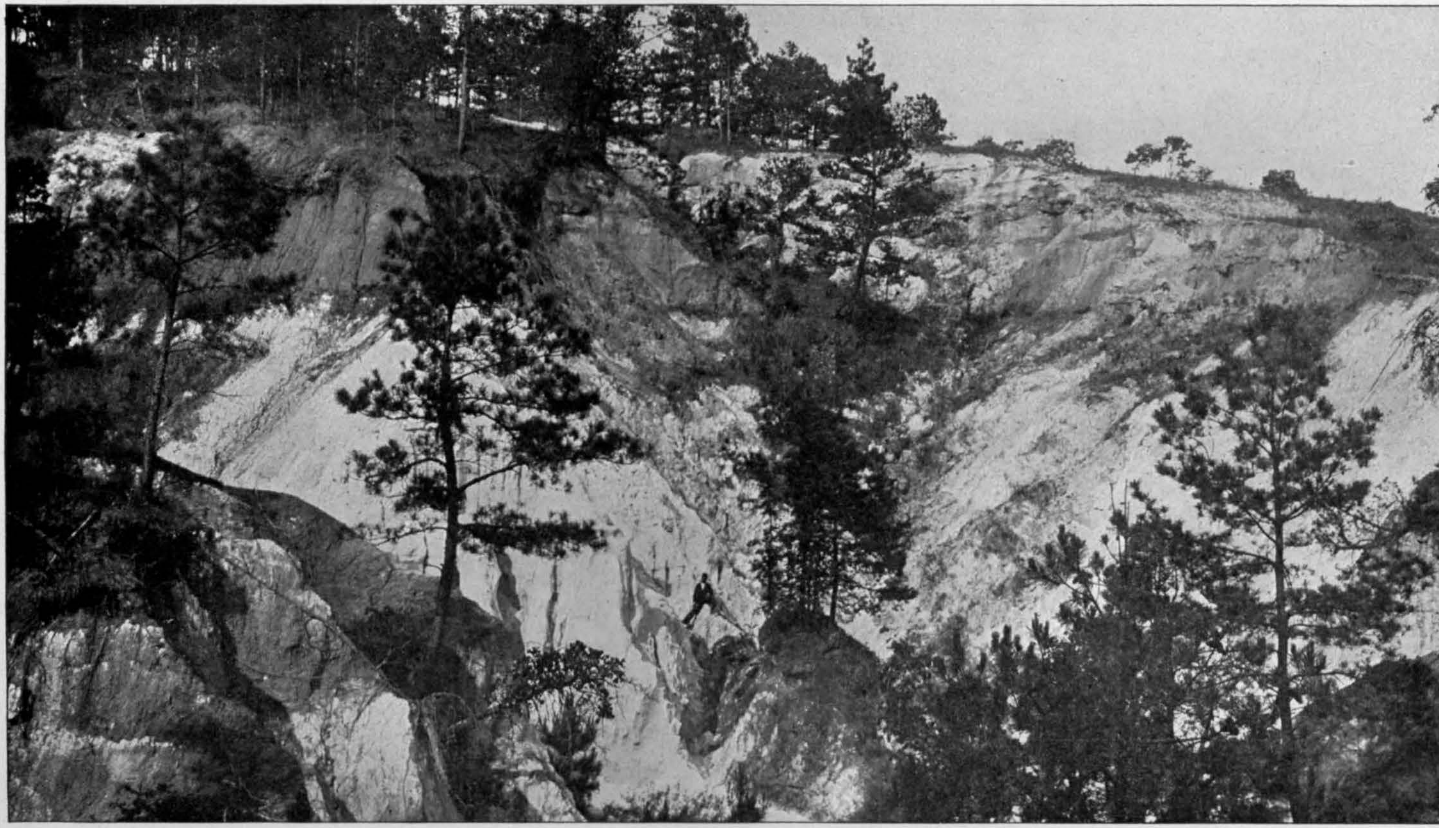
Moisture at 100° C	1.602
Loss on ignition	7.831
Silica	62.817
(Sand	40.936)
Alumina	20.748
Ferric oxide	5.120
Lime	.060
Magnesia	.487
Sodium oxide	.369
Potassium oxide	.928
Titanium dioxide	.142
Total	100.104

FULTON COUNTY

Fulton is the most populous county in the State and has an excellent market for clay products, but its clay resources are small, even for common building brick. Alluvial clays occur along the Chattahoochee River, but deposits accessible to railway lines, are being rapidly exhausted. The alluvial clay of the Chattahoochee is from 3 to 10 feet in thickness, generally very sandy, has only medium plasticity, and is red burning. The clay has good drying qualities, works well in stiff mud machines, and is free from pebbles or lime, and shows no scumming after burning.

A schist or "shale" is being used for common building brick near Chattahoochee and Bolton. This formation was probably originally a sediment, but has been so metamorphosed that its original structure and texture have been almost entirely obliterated. The schist at any place is inexhaustible for clay working purposes. The strata are highly inclined, minutely jointed and may contain thin veins of quartz. At Bolton it is soft enough to be mined with a steam shovel, though this is due to partial decomposition by weathering agencies and where unweathered the rock would doubtless be very hard. The chief objection to this rock for brick, is its poor plasticity and very low air-dried strength, resulting in a very serious loss in drying and burning unless mixed with a plastic clay. Some difficulty is met with at Bolton in crushing the schist sufficiently fine on account of the residual clay mixed with it, especially in wet weather.

A sample of the schist from Chattahoochee, ground to pass a 40 mesh sieve, showed very poor plasticity, and tensile strength not exceeding 12 pounds per square inch; its air shrinkage was 0.5 per cent. At cone 1, it burned to a dark red and to a dense almost impervious body with a shrinkage of 4.7 per cent.; at cone 5, it had a shrinkage of 10.9 per cent. and was vitrified.



CRETACEOUS WHITE CLAY AND SANDS OVERLAIN BY TERTIARY ROCKS, RICH HILL, NEAR KNOXVILLE, GEORGIA.

This schist is used by the Chattahoochee Brick Company for common building brick; 1 part of schist is mixed with 3 parts of alluvial clay.

If mixed with a small percentage of plastic clay for a bond, there is a possibility of its use for paving blocks. The experiment at any rate would be well worth trying.

The schist at the pit of the South River Brick Company at Bolton, is poorly plastic even when finely ground, has a tensile strength not exceeding 20 pounds per square inch and shows a very small air shrinkage. It burns to a dark red and is completely vitrified at cone 3.

Alluvial clay deposits can be found along the courses of the small streams of the county, though these deposits are of small extent. A small alluvial deposit of clay is used by the Capital City Brick Company, near Grant Park, Atlanta. The clay reaches a thickness of 7 or 8 feet and consists of:

1	Soil and sandy loam	1 to 2 ft.
2	Yellow sandy clay	2 to 3 ft.
3	Bluish, sandy plastic clay	4 ft.
4	Coarse sand and gravel	......

The quantity of clay in the small stream deposits does not justify the establishment of a large brick plant, and the clay is as a whole of poor quality.

The red residual clays might be used in some places; but they are generally of poor plasticity, and contain coarse rock fragments which would require crushing.

The following firms manufacture brick: Chattahoochee Brick Company, Palmer Brick Company, South River Brick Company and the Capital City Brick Company. There is one terra cotta firm, The Atlanta Terra Cotta Company, and one stoneware pottery, located at East Point. The two last mentioned firms obtain their clays from other parts of the State.

THE ATLANTA TERRA COTTA COMPANY.—This is the only company in the State, which manufactures to any considerable extent, architectural terra cotta. The output of the plant is very creditable and the product may be seen in many fine buildings in Georgia and other Southern states.

GLYNN COUNTY

There are no clay industries in this county, and no clay deposits have yet been discovered which could be utilized successfully for a large plant. Deposits of clay occur in Buffalo Swamp and other smaller swamps in the western part of the county. The deposits are of Pleistocene age, probably more recent than the Columbia sand; they are usually of small thickness and contain more or less organic matter; they are sandy, but very fine grained and plastic. The most serious objection to their use for brick, would be perhaps, difficulties of successfully drying, unless very sandy. The more plastic clays occur in pockets of restricted areas and are usually of small thickness. Professor W. S. Yeates, late State Geologist, reported having found a thickness of 8 feet at one place, but the deposits examined by him generally had a maximum thickness of only 4 or 5 feet, and were of small lateral extent. A deposit of plastic clay occurs in the swamp or marsh land along Turtle River, southeast of Bladen on the property of Dr. Archibald Smith. A sample of the clay from this locality burned red and steel hard at cone 05, but showed poor drying qualities.

GRADY COUNTY

Clays of the Altamaha formation suitable for common building brick, may be found accessible to the Atlantic Coast Line Railroad. These clays will probably be found similar in their properties to the clays at Climax and Attapulgus in Decatur county, which have been previously described. The clays may occur as greenish or drab plastic layers several feet in thickness, or as thin layers or leaves only a few inches thick, interstratified with red and yellow sand. Many of the clays are somewhat in the nature of fuller's earth, and although generally very sandy themselves, would require a mixture of sand to improve their drying and burning qualities.

GREENE COUNTY

Common building brick are manufactured by the Ogeechee Brick Company at Union Point. The clay employed is a mixture of yellow colluvial plastic clay and a disintegrated eruptive rock consisting principally of hornblende and plagioclase feldspar. The plastic clay is the residual clay derived from the igneous rock which has been transported only a short distance, being simply washed down to the foot of the hill. The section in the pit showed three feet of surface clay underlain by 5 feet of disintegrated and decomposed igneous rock. Near the contact between the clay and the rock, there are scattered lime carbonate nodules; which were probably derived from the decomposition of the hornblende and subsequently segregated as nodules. Such an occurrence of lime carbonate in a clay of this origin, is very unusual. These nodules, unless they are finely pulverized, will cause the burned brick to crack, but fortunately do not occur in large quantity and can be avoided in mining the clay.

A fair quality of building brick is made, but the plant is small and was established chiefly to supply a local demand for brick.

The following are laboratory tests on a sample of this clay; plasticity, good; tensile strength 154 pounds per square inch, air shrinkage, average, 8.7 per cent.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	1.9%	red	good body
01	1.9%	dark red	steel hard
5	.....	....	melted

Chemical Analysis

Moisture at 100° C.	2.444
Loss on ignition	7.281
Silica	47.586
Alumina	23.383
Ferric oxide	8.473
Lime	4.936
Magnesia	3.384
Manganous oxide	.062
Sodium oxide	1.118
Potassium oxide	.354
Titanium dioxide	.931
Sulphur	.139
Phosphorous pentoxide	trace
Total	100.091

HALL COUNTY

Hall county lies in the Piedmont Plateau, and the clays are red residual clays, derived chiefly from the decomposition of mica schists and gneisses, and blue and yellow alluvial and colluvial clays found along small streams. The Chattahoochee River flows across the county, but its alluvial valley is narrow and sandy, and should clays be found along its course, they are at present removed from railway lines and consequently of little or no value.

The deposits along the small streams are bluish or almost white in color, usually very sandy, have good drying qualities and burn to a light red or buff color, but do not burn to a dense body except at temperatures higher than are ordinarily employed in burning common building brick. Parts of these deposits, however, are very plastic and have been used in the manufacture of common earthenware. The residual clays are deep red, have very low plasticity, and usually contain small angular fragments of quartz and undecomposed rock. Those deposits at the base of hills attain greatest thickness and are freest from rock fragments. Experience has shown that for common building brick the best results are obtained by mixing the red residual clays and the stream deposits, both from the standpoint of economy, since the stream deposits are small and would be soon exhausted if used alone, and because a better color and harder brick at a low temperature can be obtained by the mixture.

At the time the data for this report was being collected, there were four brick yards in operation at Gainesville, and one at Oakwood, and two small potteries or "jug factories," one at Oakwood, and one at Gillsville. At the brick plant operated by G. R. Wheeler and Son, near the Southern railway station at Gainesville, a colluvial deposit of red and "white" clay is used. The clays are mixed half and half. The resulting mixture is of rather low plasticity and strength, but makes a fair grade of common building brick.

At the yard of M. D. Hudson, opposite that of Wheeler and Son, there is 14 feet of red clay underlain by 5 feet of bluish-white, more plastic clay. These clays are not in place, but are typical colluvial deposits. They are mixed ⅔ red and ⅓ "white." Similar clays are found in the pits of Mrs. P. P. Pfeffer, a short distance east.

A good quality of common building brick was being made at Oakwood by the Standard Brick Company, from a mixture of red residual clay and a deposit of bluish plastic clay occurring along a small stream.

The potteries located at Oakwood and Gillsville, are small and are not operated steadily. They manufacture jugs, jars, churns, etc., and select the most plastic clays occurring along the small streams.

The following tests of colluvial clays occurring along the Gainesville Midland Railroad, south of Gainesville, were furnished the writer by Mr. Wayne Cunningham of Savannah.

A light colored gray clay containing a high percentage of quartz and mica showed:

Air-shrinkage	*Cone*	*Fire-shrinkage*	*Total shrinkage*
5.5%	07	0.0%	5.5%
5.5%	04	0.2%	5.7%
5.3%	02	0.7%	6.0%
5.0%	1	0.7%	5.7%
5.3%	3	0.7%	6.0%
5.5%	5	0.7%	6.2%
5.0%	7	1.2%	6.2%

The clay burned to a buff color.

A yellow sandy clay of low plasticity showed:

Air-shrinkage	*Cone*	*Fire-shrinkage*	*Total shrinkage*
7.0%	07	5.5%	12.5%
8.0%	04	11.5%	19.5%
8.0%	02	12.0%	20.0%
8.0%	1	12.0%	20.0%
8.0%	3	12.5%	20.5%
8.0%	5	warped in burning	
7.5%	7	12.0%	19.5%

HARALSON COUNTY

This county is for the most part underlain by mica schists which are probably of sedimentary origin and have been highly metamorphosed. These schists are yellow or brown in color, highly micaceous, fissile, and are intersected by quartz veins. A sample was taken from a railroad cut near Dugdown P. O. for tests in the laboratory, in order to arrive at some conclusion as to its value for clay working purposes. It showed very little plasticity and its tensile strength was very low. At cone 01, it burned to a dull brown red with a shrinkage of 3 per cent., and was soft and friable. At cone 5 it was vitrified with a shrinkage of 11 per cent. The material is of little or no value for clay products on account of its lack of plasticity and air dried strength.

Alluvial clay suitable for common building brick can be found along the Tallapoosa River near where the Southern Railway crosses it. A sample was tested in the laboratory with the following results. The clay is yellow, fine grained, highly micaceous and shows rather low plasticity; it required 33 per cent. of water to develop its best plasticity and showed an air shrinkage of 5.5 per cent.; its tensile strength was (average) 50 pounds per square inch.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	2.1%	pale red	soft, absorption 20.9%
03	5. %	red	
5	8.3%	dark red	semi-vitrified

Chemical Analysis of Tallapoosa Clay

Moisture at 100° C.	0.929
Loss on ignition	5.574
Silica	66.611
Alumina	16.405
Ferric oxide	5.330
Lime	.566
Magnesia	.168
Manganous oxide	.010
Sodium oxide	.367
Potassium oxide	2.524
Titanium dioxide	1.286
Sulphur	.017
Phosphorous pentoxide	.011
Total	99.798

This clay can doubtless be successfully used for common building brick. The deposit is undeveloped and the sample tested is from near the surface, and it is likely that more plastic and stronger clay occurs deeper.

IRWIN COUNTY

This county lies within the Coastal Plain and is entirely underlain by the Altamaha formation. Sandy clays of this formation will be found beneath the mantle of loose sand which covers the surface, and in places can possibly be successfully used for brick. The clay found in the Altamaha in Irwin county will not differ materially from that found in the formation at other points in Southern Georgia. Alluvial clays can probably be found along the Ocmulgee River, though at present removed from railway lines.

JACKSON COUNTY

There are no clay industries in this county. Alluvial clays suitable for common building brick can likely be found in the valleys of the larger streams, and the more plastic of these clays will probably be suitable for common pottery. When used alone the residual clays are of little or no value.

JEFF DAVIS COUNTY

Alluvial clays will be found along the course of the Ocmulgee and Atlamaha rivers and are ultimately to be the most valuable clays in the county. They are not likely to be of great thickness, maybe averaging 3 or 4 feet, and owing to the dense vegetation growing in them, will be difficult to mine. They are fine grained, bluish or yellow in color, and very stiff and plastic; by inference from similar deposits above and below this county, they should be found suitable for brick, sewer-pipe, drain tile and roofing tile.

Alluvial clay is being used for common building brick by the Lumber City Brick Company, opposite Lumber City. The clay here is from 1 to 7 feet in thickness, having an average of probably 3 feet; the overburden is practically *nil*. If used without any admixture of sand, the burned brick are badly cracked and shivered; this is due to the very stiff plastic character of the clay, imperfect pugging, and to laminations produced by stiff mud machines in clays of this kind. The remedy is in mixing in a sand or more open clay and thoroughly mixing or pugging. The clay burns red and to a dense body at low temperatures.

Brick clays may be found at various places in the Altamaha formation which underlies the county, but these clays are inferior in quality compared with the alluvial clays, though there would be much less expense in mining them.

GULLIED SURFACE IN RESIDUAL CLAY DERIVED FROM BIOTITE GRANITE, NEAR ATLANTA, GEORGIA.

JONES COUNTY

In addition to the valuable kaolin and fire-clay beds of this county, there are deposits of low grade, plastic clays of Tertiary age, which may be of value in connection with the white clays.

These clays occur in the red sand (Claiborne group) overlying the strata bearing the kaolins and fire-clays, and are of sedimentary origin and are marine deposits; they may reach a thickness of 30 feet or more, are thinly bedded or massive; drab or greenish in color, soft, very plastic and have a high air dried strength.

A sample of Tertiary clay, from the property of J. R. Van Buren, lying just north of the kaolin deposit, 1½ miles west of Griswoldville, previously described in this report, was tested in the laboratory alone, and also mixed with the adjacent fire clay and kaolin in the railroad cut.

PHYSICAL TESTS ON TERTIARY CLAY.—The clay is very fine grained, sandy and plastic; it requires a high percentage of water for mixing, shows a high air shrinkage, 14.7 per cent., and an average tensile strength of 200 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
03	1.6%	light buff	steel hard
1	3.1%	dark buff	steel hard
4	2.9%	dark buff	not vitrified
12	cracked, no measurement		
15	6.4%	almost black	vitrified

A mixture was made, consisting of 4 parts of Tertiary clay, 2 parts of coarse sand containing a small percentage of kaolin, and 1 part of kaolin. This mixture showed a shrinkage of 9.5 per cent. and fair plasticity and strength.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
4	0.7%	light buff	not steel hard
12	1.1%	dark buff	not vitrified

The Tertiary clay should be found suitable for mixing in small percentage with the kaolin for fire-brick on account of its good bonding power and low fire shrinkage, since the kaolin itself has generally poor strength and a high fire shrinkage and cracks badly in burning. It might also be used for ornamental building brick for producing various shades of color and reducing the fire shrinkage, when the more ferruginous parts of it are selected. The tests do not indicate that vitrified products could be made by any mixture, since the vitrifying point would be too high for economic consideration.

ROBERTS.—A deposit of Tertiary shale clay is exposed in a cut of the Georgia Railroad one mile east of Roberts. The following is a geological section of this cut beginning at the top:

1	Bright red, unconsolidated sand	8 to 10 feet
2	Greenish and drab shale-clay	12 "
3	Sandy clay containing calcareous nodules	10 "
4	Bluish very fossiliferous mud	8 "
5	Decomposed crystalline rock	..

The following are tests and analysis given by Ladd[1] on clay from this point: "Specific gravity 1.80 to 2.00; fire-shrinkage 2 per cent.; fusing points 2,012° F. and 2,336° F. (determined by pyrometer); burned color, buff. Tensile strength of samples":

1 Base of beds, 143 lbs. per square inch.
2 Middle of beds, 304 lbs. per square inch.
3 Top of beds, 255 lbs. per square inch.

Chemical Analysis

Hygroscopic moisture	3.64
Loss on ignition	19.41
Combined silica	13.62
Free silica or sand	36.80
Alumina	11.56
Ferric oxide	2.20
Lime	13.89
Magnesia	1.73

1. Geol. Surv. Ga. Bulletin, 6-A, p. 147.

Potash	trace
Soda	1.36
Total, less moisture	100.57
Clay base	44.59
Fluxing impurities	19.18

It is suggested that it might be mixed with the kaolins and fire-clays to the southward for paving-brick. The high percentage of lime shown in the above analysis is unusual in the Claiborne clays, and at this point the section as a whole would show a smaller percentage of lime than that given in the analysis. The uniformity of composition of the clay is problematical. Fire-clay deposits occur a short distance southward and the indications are sufficiently favorable to at least justify experimentation on a mixture for paving blocks.

LAURENS COUNTY

Alluvial clays suitable for common building brick may be found along the Oconee River. The northern part of the county is underlain by the red sand of the Claiborne, together with some bedded deposits of sandy and calcareous clays and clay shales. The southern part of the county is generally mantled with loose Columbia sand and is underlain by the Altamaha formation, which contains thin beds of both soft and hard clays. Good exposures of this formation may be seen south of Dublin in the bluffs of the Oconee and along the Macon, Dublin and Savannah Railroad. The clays of the county are comparatively unimportant and can hardly have more than a local value.

Common building brick are being made at one locality, Dublin, from alluvial clay of the Oconee River. The clay at Dublin is of a bluish or yellow color, quite stiff and tenacious, and varies considerably in thickness and texture; it will average not more than 3 feet of workable clay, though in places it may have a thickness of 8 or 10 feet. In places there are small lime nodules about the size of a walnut, which are due to the clay being in part derived from the underlying Vicksburg-Jackson limestone. The burned brick are rather poor in quality, due to warping, and a tendency to spall or split, a defect which could be overcome by mixing in sand and thorough pugging. It has an air shrinkage of 6.6 per cent., and an average tensile strength of 148 pounds and a maximum of 180 pounds per square inch; it burned red and at cone 05 the shrinkage is nothing; at cone 5, it was very dark red and not vitrified.

LIBERTY COUNTY

The Dixie Plant of the Ludowici Roofing Tile Company is located at Ludowici, a station on the Atlantic Coast Line, and the Georgia Coast and Piedmont railroads; at this factory are manufactured unglazed, interlocking roofing tile, and it has the distinction of being the only roofing tile plant in the South.

The clay used is located near the factory on Jones Creek, a small tributary of the Altamaha River. The deposit is of Pleistocene age and is probably the equivalent of the second bottom or Columbia deposits of the Chattahoochee, Ocmulgee and Savannah rivers, and was deposited during a high stage of water in the Altamaha River. The deposit is about 6 miles distant from the river, but is at the present time occassionally flooded by back water from the Altamaha.

The clay is 4 to 7 feet in thickness, has practically no overburden and is underlain by a white water-bearing sand. It is yellowish, red and bluish in color; a mixture has a yellow color, is very fine grained; stiff and plastic. It is free from pebbles, coarse sand or coarse rock fragments. The clay is noticeably bluer, stiffer and more plastic around the roots of old stumps, and the change has evidently been effected by organic acids from the wood. The deposit is mined in small separate pits, with pick and shovel; water accumulates rapidly in the pits and drainage facilities are poor, and in mining the clay, a clay partition is left between the pits, to prevent the water which accumulates in the abandoned pits from flowing into those which are being worked. The clay is hauled in cars by mules to the plant which is about one half mile distant.

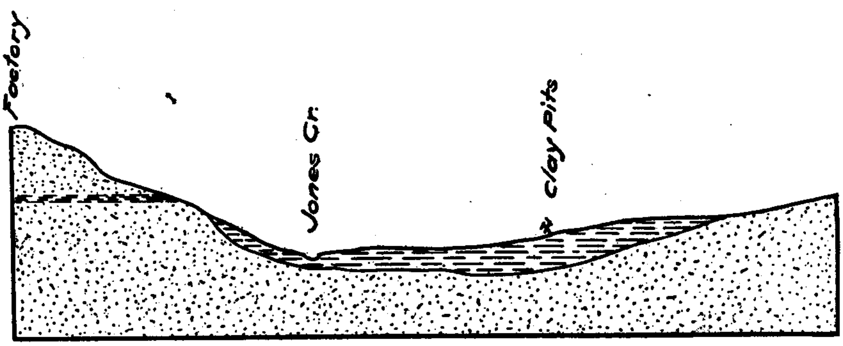


Fig. 11.—Sketch Illustrating the Occurrence of the Roofing-tile Clay at Ludowici, the Broken Lines Indicating the Clay.

At the plant, the clay is thoroughly pugged and soaked before being pressed into tiles and is burned in rectangular down draft kilns at about cone 04.

The following are laboratory tests on a sample of the Ludowici clay:

Color (raw)	yellow
Texture	very fine grained
Specific gravity	2.5
Water required for mixing	28%
Plasticity	highly plastic
Air-shrinkage (average)	8.3%
Drying qualities	tendency to warp and crack if dried rapidly
Tensile strength (average)	116 lbs. per sq. inch.
(maximum)	177 lbs. per sq. inch
Cone 05—	
Fire-shrinkage	1.2%
Color	pale red
Condition	not steel hard
Absorption	18%
Cone 03—	
Fire-shrinkage	3.9%
Color	pale red
Condition	steel hard

Cone 1—

Fire-shrinkage	4%
Color	good red
Condition	developed cracking in burning

Cone 4—

Fire-shrinkage	4.1%
Color	dark red
Condition	developed cracking in burning, not vitrified

Absorption tests were made upon a number of tiles such as are being placed on the market by the Ludowici Company from their Ludowici factory. After 48 hours immersion, the amount of water absorbed ranged from 12.5 per cent. to 16.7 per cent. The tile absorbed water rapidly and showed very little increase after the first two hours of immersion.

High absorption is not necessarily an indication that the tile can not undergo sudden changes of temperature in a rigorous climate without disintegration. As pointed out by Wheeler[1] the durability of a tile is a factor of the intermolecular strength of the burned product, and a porous tile may withstand frost action as well as a tile of low absorption on account of the greater intermolecular strength of the former and its ability to withstand the expansion of freezing water in its pores on account of the strength of the clay partitions between the pores.

The following is a chemical analysis of a sample of the Ludowici clay:

Moisture at 100° C.	5.169
Loss on ignition	8.959
Silica	57.302
(Sand	27.163)
Alumina	20.026
Ferric oxide	6.381
Lime	.161
Magnesia	.442
Manganous oxide	trace
Sodium oxide	.260
Potassium oxide	.485
Titanium dioxide	1.364
Sulphur	trace
Phosphorus pentoxide	trace
Total	100.549

1. H. A. Wheeler, Trans. Amer. Cer. Soc. Vol. VIII, p. 154.

LOWNDES COUNTY

There are no clay industries in this county and the clay deposits so far as known are of little relative economic importance. A mottled, sandy clay, similar in appearance to the Altamaha clays elsewhere, was noted in a cut of the Atlantic Coast Line Railroad between Kinderlou and Ousley. A bluish sticky sandy clay was also noted in the banks of the Withlacoochee River near Olympia, but it does not give much promise of being of value, even for brick purposes. Deposits of swamp clay could probably be found along the Allapaha River in the eastern part of the county.

McINTOSH COUNTY

The surface of McIntosh county is low, flat and swampy, and is covered with sand. The only clays known are deposits of restricted area occurring in swamps, or in depressions which have formerly been swamps. Bluish muds are reported in the coastal marshes. There are two brick plants in the county, one at Townsend, The Townsend Brick Company, and one near Theo or Darien Junction, The Altamaha Brick and Tile Company.

The Townsend Brick Company is using a swamp deposit which attains a thickness of 4 or 5 feet; the clay contains a high percentage of organic matter, decayed vegetation, and when wet is almost black in color; it is quite sandy, on an estimate containing probably 75 or 80 per cent. of quartz sand, and consequently has very little shrinkage, and in burning there is probably an expansion. Roots of trees and poor drainage are difficulties encountered in mining. The burned brick are a dull gray and when hard burned are almost a blue. The explanation of this color may be due to the carbonaceous matter preventing the oxidation of the iron and leaving it in a ferrous condition.

The clay on the property of the Altamaha Brick and Tile Company, has an average thickness of about 5 feet and is underlain by water bearing sand. Near the surface the clay is quite sandy and contains carbonaceous matter, but is more plastic, deeper. Drainage facilities are poor and water has to be pumped from the pits even in fair weather. The burned brick are red and when the clay is not too sandy are of fair quality.

MACON COUNTY

Alluvial clays occur along Flint River, which can be used for building brick. The alluvium is generally very sandy and of small thickness, averaging probably not more than 4 feet; but stiff plastic clays may be found in places. A small brick plant is being operated near Oglethorpe.

The clay occurs in the second bottoms, which are swampy and covered with dense vegetation, and unless the land has been cleared for some time, the mining of the clay would be expensive on account of roots of trees.

MERIWETHER COUNTY

Meriwether county lies within the province of the Piedmont Plateau, and the rocks are mainly granites and granite-gneisses, with schists and quartzites in the southern part of the county. The residual clays can not be expected to be of much value for clay products. Alluvial clays may be found along the larger streams, and should be found suitable for common building brick. A small sample of alluvial clay from the property of J. R. Betts near Woodbury, was coarse grained, sandy and micaceous, but developed a fair plasticity and showed an air-dried strength of 60 pounds per square inch. At cone 01, it burned to a light red and showed a total shrinkage of 8.4 per cent. Mixed with a more plastic or less sandy clay, it would probably be well adapted for com-

BRICK PLANT OF THE ARNOLD BRICK COMPANY, THOMASVILLE, THOMAS COUNTY, GEORGIA.

mon building brick. The writer has no information as to the extent and thickness of the deposit.

MITCHELL COUNTY

The eastern half of Mitchell county is underlain by the sands and sandy clays of the Altamaha formation, while the western half along Flint River is underlain by the Vicksburg-Jackson limestone and the whole is covered by a thin mantle of loose gray Columbia sand. Clays can probably be found along Flint River and are not likely to differ greatly from those described in Dougherty county.

The following section of Altamaha clay is exposed in a cut of the Atlantic Coast Line Railroad, two miles north of Pelham:

1	Red and gray splotched clayey sand, case-hardened by an iron oxide cement	4 feet
2	Greenish or drab, laminated, fine-grained clay	5 "
3	Laminated, gray, clayey sand, with purplish splotches	4 "

This clay could possibly be used for common building brick, but may be expected to have objectionable properties similar to the Climax clay of Decatur county.

MONTGOMERY COUNTY

Deposits of alluvial clay occur in the swamp land along the Oconee River and may prove to be valuable clays. They are undeveloped and unprospected, except at one point near Mt. Vernon, where a deposit is used for common building brick by Messrs. Mason and Bland. The brick plant is located on the Seaboard Air Line Railroad about 2 miles west of Mt. Vernon station. The clay used lies in wooded swamp land; it is very fine grained, plastic and free from coarse sand and pebbles; so far as it could be ascertained it was about 4 feet in thickness. There is no overburden; difficulties in mining are experienced from roots and water. Similar deposits can probably be found both above and below this point.

Physical Tests on Oconee River Clay, Mt. Vernon.—The clay is very fine grained and plastic; it requires a high percentage of water to develop its best plasticity; tensile strength, average, 172 pounds per square inch; air shrinkage, average, 9 per cent. When the strong plastic clay is used alone, its drying qualities are poor.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
07	2.1%	pale red	soft
04	6.8%	pale red	steel hard
01	7.1%	light red	exterior vitrified
2	7.4%	dull red	exterior vitrified
4	9.1%	dark red	vitrified, swelling
14	.....	very dark	vitrified, cracked badly

The clay is somewhat similar to the Ludowici roofing tile clay. It shows a slightly higher air shrinkage, and a higher fire shrinkage, but is more plastic and stronger and contains a smaller percentage of sand. The burned color is similar, but it burns to a denser body at lower temperatures. It has serious disadvantages for common building brick, unless mixed with sand or sandy loam, on account of poor drying qualities and a tendency to crack in burning.

The following is a chemical analysis of the more plastic clay:

Moisture at 100° C.	4.140
Loss on ignition	10.810
Silica	50.080
(Sand	12.620)
Alumina	26.732
Ferric oxide	5.950
Manganous oxide	trace
Lime	.240
Magnesia	.371
Sodium oxide	.413
Potassium oxide	.637
Titanium dioxide	1.118
Sulphur	.000
Phosphorous pentoxide	.000
Total	100.491

MUSCOGEE COUNTY

Alluvial clays of the Columbia age, occur in the first terrace above the Chattahoochee River and are being used extensively for common building brick at Columbus. There are at present three plants in operation: G. O. Berry and Company, Sheperd Brothers, and the Muscogee Brick and Terra Cotta Company. The clays lie in the terrace, 40 to 50 feet above the river; they are generally very plastic, but will vary in texture and thickness; they have been derived from the crystalline rocks of the Piedmont region and are free from lime nodules and any objectionable soluble salts. They are at present being used only for common building brick, but some of them also offer possibilities for sewer pipe, drain tile, and common pottery.

The following section was made in the pit of G. O. Berry and Company:

1	Sandy soil	1 to 2	feet
2	Bluish, very plastic clay	4 to 5	"
3	Blue, sandy, plastic clay	6	"
4	Sandy, micaceous clay, with occasional pebbles	2½	"

The following physical tests and the chemical analysis were made from a sample of the more plastic clay and not upon the brick clay mixture.

The clay is a light yellow in color, very plastic and required 45 per cent. of water to develop its maximum plasticity; air shrinkage, average, 9.1 per cent.; tensile strength, average, 154 pounds per square inch. In the manufacture of common building brick, sandy clay is mixed with the more plastic clay, thus reducing the air shrinkage and improving its drying, and burning qualities, and a good common building brick is produced.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	5.0%	very pale red	steel hard
03	6.0%	pale red	steel hard
1	6.3%	" "	black core
4	7.4%	" "	vitrified
13	7.1%	dark color	slightly blistered and warped

Chemical Analysis

Moisture at 100° C	2.317
Loss on ignition	11.833
Silica	49.411
(Sand	22.715)
Alumina	28.649
Ferric oxide	5.586
Lime	trace
Magnesia	.366
Manganous oxide	trace
Sodium oxide	.424
Potassium oxide	.112
Titanium dioxide	.920
Total	99.618

The clays at the Berry yard and at Shepherd Brothers are quite similar.

MUSCOGEE BRICK AND TERRA COTTA COMPANY.—The brick plant of this company is located on the Central of Georgia Railway, 3 miles east of Columbus. It is one of the best equipped plants in the State. The clay used is a Pleistocene deposit along Bull Creek, forming a plain about 15 feet above the creek. The general section of the deposit is:

Sandy soil and sand	1 to 2 feet
Stiff, plastic clay	0 to 8 "
Coarse sand and gravel	

The deposit as a whole is quite variable and is objectionable because of its lack of uniformity. The clay is fine grained, stiff and tenacious and is difficult to work in a stiff mud machine and cracks badly in drying, unless mixed with sand or sandy loam. It is necessary to use such a large percentage of sand that the burned brick are porous and have low strength. The sand associated with the clay is often quite coarse.

It is possible that a schist could be found a few miles to the northward, which could be mixed with the clay, to improve its drying qualities and working qualities and at the same time reduce the fusion point of the clay and produce a harder brick at a low temperature, which can not be effected by the use of sand as an anti-shrinkage agent, since the stiff clay is not within itself easily fusible and the sand increases its fusing point.

NEWTON COUNTY

The clays of Newton county are only of local importance; they consist of red residual clay derived from granites and gneisses and deposits of alluvial clays suitable for common building brick. Small brick plants are located at Covington and Starrsville. The plant at Covington is located 1½ miles northwest of town on the Georgia Railroad, and is using an alluvial deposit along a small stream. The clay burns to a buff color and the brick are porous and otherwise of poor quality. The clay deposit is small.

Anderson Brothers operate a small plant near Starrsville on the Central of Georgia Railroad. The clay deposit lies in the bottom land of Alcovy River and is alluvial and partly colluvial in origin; the clay is bluish-white, quite sandy but has a good brick clay plasticity. The deposit showed a thickness of 5 feet or more and probably underlies a considerable area. The plant is small and is operated only a part of the year.

Physical Tests.—Coarse grained, very sandy, plasticity fair; air shrinkage, 6 per cent.; drying qualities good, and it possesses sufficient air dried strength to insure handling without any great breakage.

Cone	*Fire-Shrinkage*	*Color*
07	1.2%	salmon
03	5.6%	"
1	6.9%	red
5	7.2%	dark buff

The clay is very sandy and will not burn to a deep red color nor to a dense body at low temperatures. It shows no sign of warping or cracking in burning; and if properly worked and burned, is capable of making a fair grade of common building brick.

The brick, if made by the stiff mud process, will show a tendency to laminate, and the clay would have to be crushed on account of the coarse quartz fragments that it contains.

Clay deposits will be found along nearly all of the streams of the county, but the extent and quality of such clays will rarely justify any large plant for their utilization.

Chemical Analysis of Starrville Clay

Moisture at 100° C.	1.605
Loss on ignition	8.458
Silica	58.456
Alumina	23.262
Ferric oxide	4.622
Lime	.190
Magnesia	.360
Manganous oxide	trace
Sodium oxide	.524
Potassium oxide	2.270
Titanium dioxide	.460
Sulphur	trace
Phosphorous pentoxide	trace
Total	100.207

OCONEE COUNTY

A small pottery where jugs, jars, flower pots, etc., are manufactured, is located at Bogart and owned by J. D. Brewer. The equipment consists of a small pug mill run by a traction engine, two potters' wheels and an oven with a capacity of about 600 gallons. Only a small quantity of clay is required and this is obtained from the valley of a small stream to the north of Bogart. Alluvial and colluvial deposits can probably be found along the streams, but such deposits may be expected to be very limited except along the larger streams. The residual clays are of little or no value for clay working purposes.

OGLETHORPE COUNTY

The clay of the "flatwoods" country in the eastern part of the county, may prove to be of some economic value in the future, but is now too far removed from railway lines to be of any value. There are no clay industries in the county.

PAULDING COUNTY

Common brick for local uses have been made at Dallas and Hiram. Brick clays may be found along the small streams, though in limited quantity. The residual clays are at present valueless for clay products.

PIERCE COUNTY

The only geological formations exposed in this county are the Columbia sand and the Altamaha formation. In the latter will be found inter-stratified plastic clays and sands, and the clays may be expected to have properties similar to the clays of the same formation now being used at Odessa and Waynesville in Wayne county.

POLK COUNTY

The decomposed metamorphic shales and the slates of the Rockmart formation afford some material of value to the clay worker.

Carlton Clay Pit.—A very interesting clay is being mined by H. M. Carlton, 4 miles east of Rockmart. The deposit is in a hill between the Seaboard Air Line and Southern Railroads, and the clay is hauled to Beatty Switch about 1 mile distant from the mine.

The clay is a highly decomposed metamorphic shale lying near the base of the Rockmart formation. The shale is soft and friable but retains to some extent its original structure, and has a ligneous or woody texture similar to the so-called "Caen" stone south of Rockmart. The clay pit has a face of 15 feet in which the shale is decomposed, and is generally a cream, or light yellow color, and is overlain by 30 feet of brecciated chert and sandstone, which is in places a low grade iron ore. The clay has an unctuous, talcose feel but may contain geodes or drusy cavities of quartz crystals. The decomposed rock such as seen in the pit, is evidently in great quantity and sufficient for any clay working purposes for which it may be adapted.

This material is being used for terra cotta purposes, though the demand for it is small and the price about $1.00 per ton, is no encouragement for extensive mining.

The following physical tests were made in the laboratory of the Geological Survey by the writer:

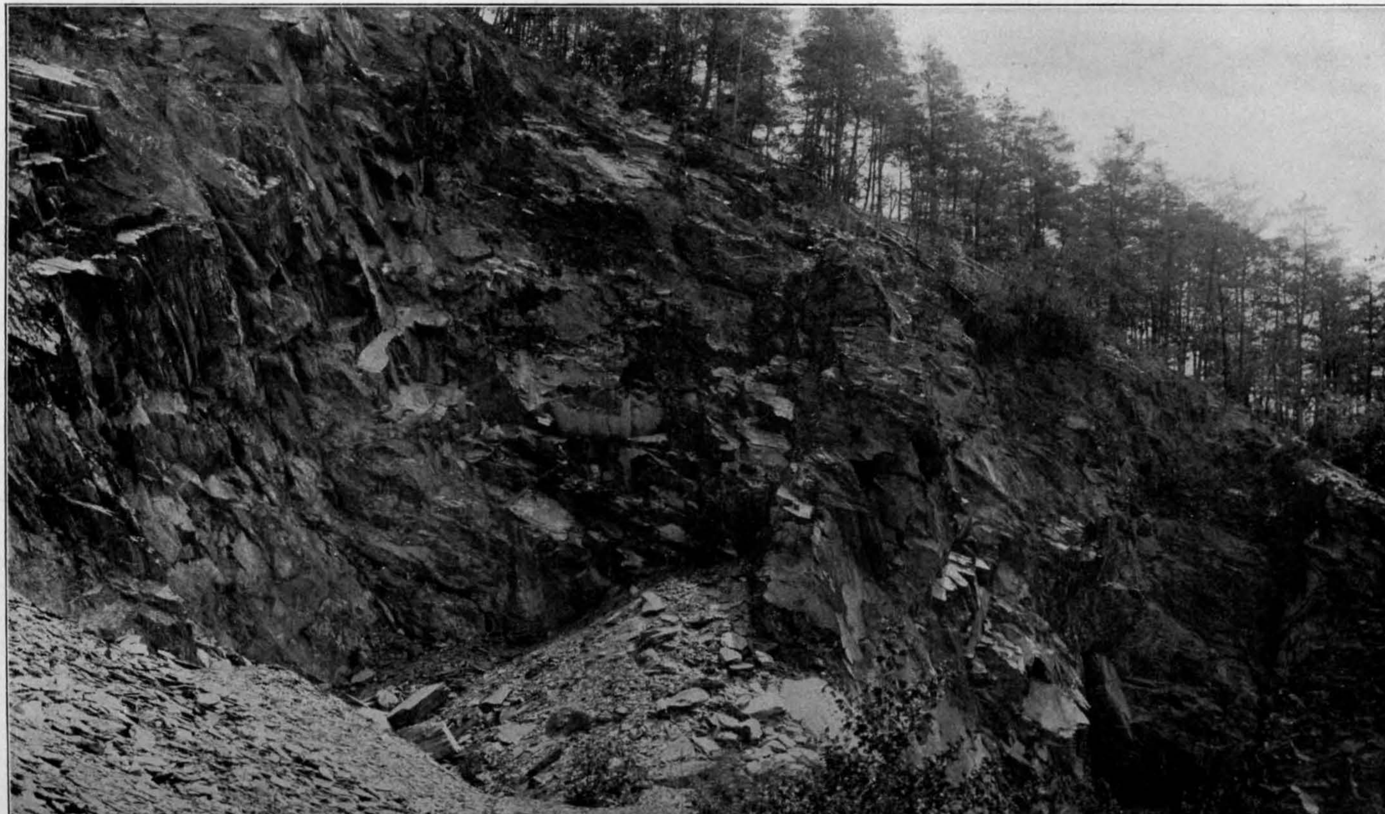
Color, a light buff or cream; soft, but requires crushing; very poorly plastic; low tensile strength, not exceeding 12 pounds per square inch. The burning tests were as follows:

Cone	*Fire-Shrinkage*	*Color*
05	......	pale buff or cream
03	4.1%	cream
4	11.9%	buff
14	12.0%	dark gray, buff

At cone 05, the clay was soft and friable and showed very little change from its raw color; likewise at cone 03, it was soft. At cone 4, it was vitrified, and showed black specks of iron. At cone 14, it showed complete vitrification and glistening specks of iron. Its fusing point was cone 18, and it is not a fire-clay. On account of its lack of plasticity and low strength, it can not be used alone, but is an excellent material for terra cotta mixtures since it burns to a very dense body and a light color at the temperatures used for burning terra cotta. It showed no cracking or warping up to cone 4.

Chemical Analysis of Carlton Clay

Moisture at 100° C.	0.103
Loss on ignition	3.922
Silica	67.565



Slate Quarry, Rockmart, Polk County, Georgia.

Alumina	20.796
Ferric oxide	2.002
Lime	.578
Magnesia	1.064
Sodium oxide	1.070
Potassium oxide	2.056
Titanium dioxide	1.104
Total	100.260

The shales and "Caen" stone of the Rockmart formation and their weathered residue, will probably be found adapted for building brick, but the chief fault of such material will be low plasticity and low dried strength. The unweathered material might be more successfully used by the dry press method.

The following is an analysis of the "Caen" stone, which is an altered metamorphosed shale. It probably received the name "Caen stone," from a fancied similarity to the famous French building stone from Caen.

Water	4.88
Silica, SiO_2	64.28
(Sand	30.14)
Alumina, Al_2O_3	21.15
Ferric oxide, Fe_2O_3	5.77
Lime, CaO	trace
Magnesia, MgO	0.09
Soda, Na_2O	.92
Potash, K_2O	3.62
Phosphorous pentoxide, P_2O_5	trace
Total	100.71
Fluxing impurities	10.40

The above analysis indicates a red burning clay of low fusibility.

Caen Stone.—A sample of the "Caen" stone from near Rockmart, having a yellow or brownish color and the characteristic ligneous texture, was tested in the laboratory. Ground to pass a 40 mesh sieve, it showed little or no plasticity and a tensile strength not exceeding 8 or 10 pounds per square inch; its air shrinkage was 1 per cent. Burned at cone 05, it showed good uniform red color and showed a shrinkage of 4 per cent.; there was no warping or cracking, but the bricklet was very porous. At cone 1, it burned to a dark red; fire shrinkage, 6.5 per cent., and was steel hard. Such material as the unweathered shale can not be used for brick successfully by the stiff mud process, unless mixed with a plastic clay. The weathered shales mixed with the residual surface clay derived from the shales, should produce a brick of good color and density though the defect of even such a mixture is most likely to be low plasticity and strength.

PULASKI COUNTY

Alluvial clays suitable for common building brick may be found along the Ocmulgee River. The clays will probably be found in less extensive deposits than those above in Twiggs and Bibb counties, and some of them have lime nodules distributed through them, which are derived from the Vicksburg-Jackson limestone. The second bottoms will generally be found very sandy and the more plastic clays will be found in the lower or swampy land.

Common building brick are manufactured by the Hawkinsville Brick Company, at Hawkinsville. The clay used is a river alluvium, but is free from lime nodules. It is a yellow or red in color, sandy, has fair plasticity, and can be made into a good grade of common building brick. A sample tested in the laboratory showed an average air shrinkage of 5.8 per cent.; required 21.5 per cent. of water for mixing, and gave a tensile strength of 98 lbs. per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	3.6%	pale red	soft, porous
03	5.6%	" "	steel hard
1	4.6%	red	steel hard
5	8.0%	"	not vitrified
12	7.2%	"	warped, not fused

The clay has good air drying qualities and shows no cracking in burning at low temperatures. The best quality and color of brick could probably be obtained by burning the clay at a higher temperature than is employed at present.

Chemical Analysis of Hawkinsville Clay

Moisture at 100° C.	1.97
Loss on ignition	8.78
Silica	57.12
(Sand	26.16)
Alumina	23.42
Ferric oxide	5.70
Manganous oxide	trace
Lime	trace
Magnesia	.45
Sodium oxide	.21
Potassium oxide	.67
Titanium dioxide	1.29
Sulphur	.00
Phosphorous pentoxide	.00
Total	99.61

A small brick plant is in operation at Ainslie, on the Southern Railway.

QUITMAN COUNTY

Alluvial clays of Columbia age occur along the Chattahoochee River, lying in the first terrace about 40 feet above the river. These clays are being used for common building brick by the Eufaula Brick Company, opposite Eufaula, Ala. The alluvium as a whole is very sandy and variable in character, and the more plastic clays occur in pockets separated by humps of sand. The clay on the property of the above brick company is from 1 to 7 feet in thickness and is underlain by fine yellow to gray, micaceous sand, and is overlain by about one foot of sandy soil. It is a bluish to reddish-brown in color and may be fine grained and plastic or sandy and very "short." It is free from pebbles and is easily mined. The plastic and sandy clays are mixed. The following laboratory tests were made on a sample of the mixture employed at the plant.

Plasticity, good; water required, 23 per cent; air shrinkage, average, 6.3 per cent.; tensile strength, average, 119 lbs. per square inch.

Its drying qualities are good and it shows no tendency to scum either upon drying or burning.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	0.7%	salmon	soft
1	1.1%	dark brown	steel hard
5	3.4%	" "	not vitrified

The clay shows a low fire shrinkage; it will burn into a hard, tough and durable brick, but will not be impervious on account of the high sand content.

Chemical Analysis

Moisture at 100° C.	1.70
Loss on ignition	5.72
Silica	70.64
Alumina	15.64
Ferric oxide	3.74
Manganous oxide	.03
Lime	trace
Magnesia	.46
Sodium oxide	.32
Potassium oxide	1.17
Titanium dioxide	1.10
Sulphur	.00
Phosphorous pentoxide	.00
Total	100.52

Alluvial clays can doubtless be found both above and below Georgetown, though at present not accessible to transportation. The first terrace is prominently developed from Columbus southward and at almost any point contains good brick clays.

RICHMOND COUNTY

Alluvium of Pleistocene age, of the first terrace above the Savannah River, is extensively used for common building brick near the city of Augusta. The alluvial clay occurs in a flat sandy plain about 2 miles in width, and 30 to 40 feet above the Savannah River; this terrace deposit was laid down probably in Pleistocene time during an inundation stage of the present Savannah River. It consists chiefly of loose sand with local beds of small gravel, and deposits of sandy and plastic clays. The workable clay generally has a thickness of 6 to 12 feet, but is reported at one place to have a thickness of 32 feet; as a whole the clays are too coarse and sandy to be of any value for other products than common building brick.

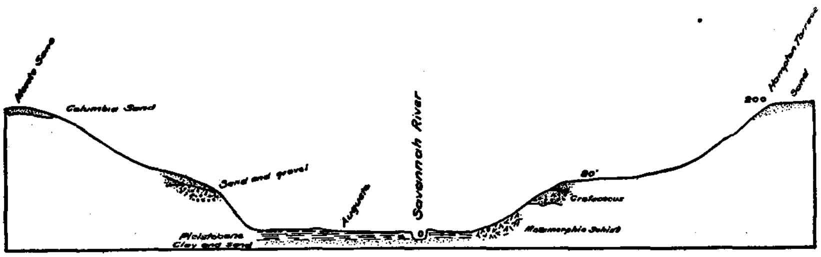


Fig. 12.—Generalized Cross-Section of the Savannah River Valley at Augusta.

A very durable, dark red brick can be made, but in the case of the more sandy clays, the brick are rough, soft and very porous unless burned hard. The air-shrinkage of the clay is not excessive, and it has generally good drying qualities; the air-dried strength is good, except in the case of some very sandy clays, the green brick from which are broken badly in handling.

The sand layers underlying the clays are nearly always water bearing and at some places difficulty is experienced in keeping the pits drained.

The following companies are at present engaged in the manufacture of common building brick: McCoy Brick and Tile Company, McKenzie Brick Company, Merry Bros., B. S. Dunbar, Standard Brick Company, Branch and Company.

The best exposure of the clay was seen in the pit of the McKenzie Brick Company. The clay here is reported to have a maximum thickness of 32 feet; only about 12 feet, however, is worked; this is bluish to yellow, quite sandy and very variable in texture. There are pockets of almost pure sand, and the clay contains scattered accretions of yellow and black iron oxide, similar to the alluvial clay at Macon. The lower clay is reported finer and more plastic than that which is being used. There are pockets or layers of sand through the clays which are water-bearing; one of these sand layers extends entirely across the pit a distance of about 100 yards. The clay is 12 to 15 feet thick and a wall of clay about 100 feet in length is mined at four different points simultaneously, which insures a good mixture of the clay. In mining, the wall is undermined, stakes are driven in at the top, and the clay falls by gravity.

Belair.—An altered schist is being mined at Belair by the Georgia Vitrified Brick and Clay Company, and is being used at their plant at Campania, mixed with a plastic clay, in the manufacture of paving blocks and sewer pipe. This material was probably originally a sediment, perhaps a very siliceous shale, but has been so metamorphosed, that nearly all trace of its original texture and structure has been obliterated. This belt of schist extends eastward to Augusta, being exposed at Murray Hill, and near Wheeless station, and into South Carolina. An excellent exposure preserving to some extent the original structure, is seen in the bluffs of the Savannah River at North Augusta, S. C. The belt is also known to extend several miles south of the Georgia Railroad, and is overlain by a variable thickness of Cretaceous, Lafayette and Columbia sands and clays. These schists are of little value if used alone since they are lacking in plasticity and air-dried strength but are suitable for certain clay products when mixed with a plastic clay for a bond. The quantity available for use depends upon the depth to which decomposition by weathering has taken place, since where unweathered, the schists are hard and crystalline. The weathered schists are vari-colored, white pink, yellow, red and greenish and vary in composition; they are pulverulent or ocherous or quite hard, requiring blasting; certain weathered portions at Murray Hill, 3 miles north of Augusta have been used as a paint material. The schists are cut by small quartz veins.

The clay is being mined from two pits or quarries at Belair. The rock here will probably be found weathered to a depth of 40 or 50 feet, beneath this depth the material will be hard and more crystalline and more uniform, but less suitable as a clay material. Near the contact with the overlying Cretaceous sand and gravel, the schists may be almost pure white, and composed almost entirely of very fine silica, 90 per cent. or more. For use at the plant at Campania, the schists or "shales" are selected, not all of the weathered product being of value, and some difficulty is experienced on account of its variable composition.

The greenish and yellow semi-decomposed "shale" has little or no plasticity, low tensile strength, not exceeding 8 or 10 pounds per square inch, and low fusibility; both air and fire shrinkage is low. The darker colored "shales" are higher in iron and fluxing impurities, and hence of most value for clay products, as paving blocks and sewer-pipe. A sample of the "gray shale" from the north quarry at Belair, was vitrified at cone 4 and completely fused at cone 11.

The plastic fire clays of the Cretaceous in Richmond county should be suitable for mixing with these schists.

SPALDING COUNTY

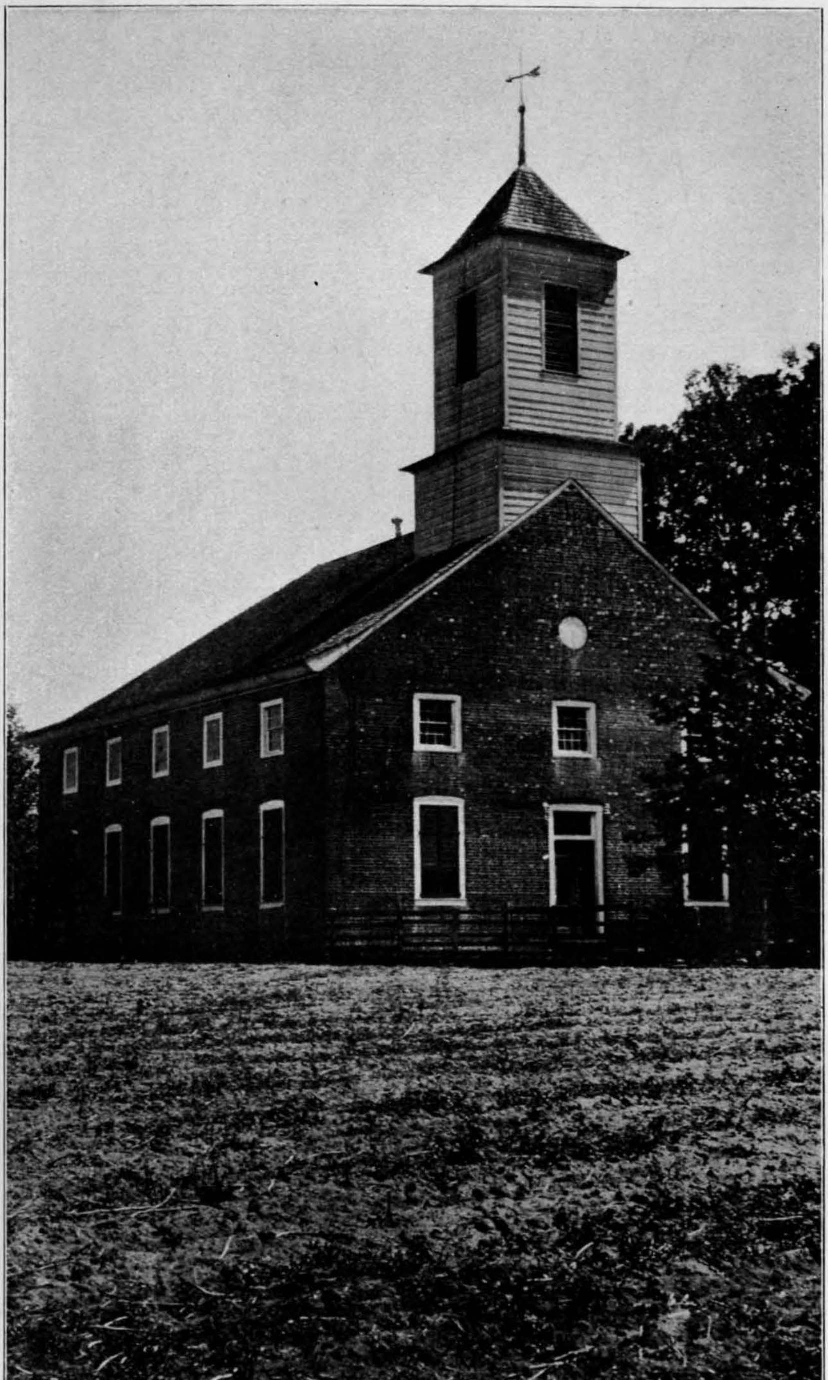
The clays of this county are only of local importance. Small brick yards have been operated from time to time, but only to supply a local demand for brick. Dr. T. Ellis Drewry operated a small brick plant near Griffin, and a part of the Rushton Cotton Mills factory was built of the brick made at this plant. The clay used was a mixture of red residual surface clay and the more plastic clay occurring in the valley of a small stream. A very durable brick was made.

The clay in the vicinity of Griffin is in no place in sufficient quantity to warrant the establishment of any extensive brick industry. Alluvial clays can be found along Flint River in the western part of the county, and if properly worked, should make a good quality of building brick. The clays are undeveloped and the writer has no information as to the thickness of the deposits.

A small sample of clay sent to the writer by Miss Minnie Williams of Brooks, and reported as coming from near the junction of Line Creek and Flint River, was bluish-white in color, very plastic, showed a tensile strength of 64 lbs. per square inch, is semi-refractory, and should be found suitable for use in stoneware and terra cotta mixtures.

STEWART COUNTY

Building brick are being manufactured by the Chattahoochee Valley Brick Company, at Omaha, from alluvial clay from the first terrace of the Chattahoochee River. The clay is of Pleistocene or Columbia age and lies in a flat alluvial plain about 40 feet above the river; it is similar in occurrence and in the same position as the alluvial clay at Columbus, Georgetown and Ft. Gaines. The clay at Omaha is very stiff and plastic and is from 4 to 12 feet in thickness. It is necessary to mix sand or sandy loam with it in order to improve its working and drying qualities. The following are physical tests made in the laboratory by the writer: Plasticity, very good; rather stiff and tenacious; air shrinkage, high, 11.1 per cent.; air drying qualities, poor; tensile strength, average, 199 pounds per square inch.



Ebenezer Church, Effingham County, Georgia, Built in 1769 of the First Brick Made in Georgia.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
03	3.1%	red	steel hard
1	3.1%	red	slightly warped
4	5.9%	dark red	warped
12	.....	black	vesicular

Both the drying qualities and burning qualities could be improved by admixing sand, but at the expense of the density of the burned product.

Chemical Analysis

Moisture at 100° C	3.488
Loss on ignition	7.787
Silica, SiO_2	60.888
(Silica, sand	32.520)
Alumina, Al_2O_3	19.192
Ferric oxide, Fe_2O_3	6.230
Lime, CaO	.219
Magnesia, MgO	.834
Soda, Na_2O	.498
Potash, K_2O	.334
Titanium dioxide, TiO_2	.918
Phosphorous pentoxide, P_2O_5	trace
Sulphur, S	.109
Total	100.497

The black, laminated, micaceous clays and clay-marls of the Ripley division of the Cretaceous are exposed in numerous places, and may be of future value for clay products.

SUMTER COUNTY

There are no developed clay deposits in the county. It is for the most part underlain by the Vicksburg-Jackson formation, consisting of a flinty limestone and red and yellow sands which contain thin clay layers. The white clays of the Midway formation in the northern part of the county have been previously described. Alluvial clays suitable for common building brick could possibly be found along Flint River in the eastern part of the county. Brick have been burned near Americus, on Muckalee Creek, about one-fourth a mile west of town. The brick seem to have been poor in quality.

TATTNALL COUNTY

Tattnall county is entirely underlain by the Altamaha formation, which is covered by a thin superficial layer of gray, Columbia sand. The Altamaha formation is for the most part a yellow and red sand containing coarse angular quartz fragments or pebbles. Unlike the formation in some other counties, there is but little clay near the surface, but sandy clays could be found which might be used to supply a local demand for brick. There is an exposure containing some clay in a cut of the Seaboard Air Line Railroad between Lynn and the Ohoope River. There is some probability of excellent clays occurring in the swamp lands of the Altamaha River which forms the southern boundary of the county, though this region is at present removed from railway transportation.

TELFAIR COUNTY

Plastic, sandy clays of sedimentary origin are exposed in the cuts of the Southern and Seaboard Air Line railroads. These clays belong to the Altamaha formation, and have similar properties to the Altamaha clays elsewhere over southern Georgia; they are variable in thickness and texture, and have objectionable properties for clay products, but might be used for supplying a local demand for brick, though the quality of such clays doubtfully warrants the establishment of any large plants. About one mile northwest of Helena, in a cut of the Southern Railway, the following section was observed:—

1	Loose gray sand, Columbia	1 foot
2	Mottled, clayey sand	6 feet
3	Drab, laminated sandy clay	3 "
4	Coarse grit	4 "
5	Greenish, plastic, laminated clay	6 "

The different layers will be variable in thickness, being rather in the form of lenses, and the coarse grit may be locally indurated. There are some small pebbles in the sand, but these rarely exceed an inch in length. A sample of clay from layer No. 5, showed good plasticity; required a high percentage of water for mixing; good air dried strength; air shrinkage, 10.4 per cent. It burned to a light red color and at cone 1, burned steel hard with a shrinkage of 3.7 per cent.

It would require a small percentage of sand to improve its drying qualities and it should be thoroughly pugged. The iron oxide is the chief fluxing impurity, and the other common fluxing impurities are in only very small amounts.

Alluvial clays of good quality may be expected along the Ocmulgee River in the southern part of the county, but until this region is opened up by a railway line, would be of no value.

THOMAS COUNTY

The only clays in Thomas county which seem likely to be of any value, are those of the Altamaha formation, which is the surface formation over the greater part of the county. Greenish or gray sticky, sandy clays, containing phosphatic nodules occur overlying Oligocene limestone in the southern part of the county, but their use for brick has not been attempted, and they are doubtfully of any value. This clay may be seen in the old phosphate pit, 3½ miles west of Boston.

The Arnold Brick Company is operating a small brick plant on the Atlanta, Birmingham and Atlantic Railroad, 2 miles north of Thomasville. The clay here occurs in the Altamaha formation, and has been somewhat altered from its original condition from having been covered by a pond. The section in the pit at the time of my visit was:

1	Dark gray sandy clay	1 to 2 feet
2	Gray, "tallow" clay, with iron oxide splotches	2 to 3 "
3	Drab, very stiff, tenacious clay	3 "

The lower clay is so stiff and tough, that it cannot be used alone and worked through a stiff mud machine, but has to be mixed with the sandy clay at the surface. The burned brick are red or buff, depending upon the mixture used. An idea of the character of the lower clay can be ascertained by referring to the tests on page 254.

TIFT COUNTY

The sandy clays of the Altamaha formation might be used to supply a local demand for common building brick. The clays are of sedimentary origin, and occur as thin irregular layers in vari-colored sands; they are generally quite sandy and gray or mottled, and possess good plasticity. They may be observed at a number of localities in railroad cuts and wagon road cuts, and have pretty much the same lithological character at all points.

A small sample of clay from near Tifton, tested in the laboratory, showed fair plasticity, notwithstanding that it contained probably 60 per cent. of sand; gave a tensile strength of 50 pounds per square inch and showed an air shrinkage of 8.8 per cent. Burned at cone 05, about the temperature ordinarily employed in burning common building brick, it showed no fire shrinkage and was porous and soft. Such clay could be used for building brick, though a first class brick can not be expected on account of the necessity of using a high percentage of sand to improve the working qualities of the clay.

Many exposures may show light or almost white clays, but none of these are kaolins or china clays.

TOOMBS COUNTY

Toombs county is entirely underlain by the Altamaha formation. The typical yellow and red mottled sands and sandy clays are exposed at the surface. An excellent exposure showing a large amount of clay, can be seen in a cut of the Seaboard Air Line Railroad, about one-half mile east of Ohoopee

Station. The Altamaha River forms the southern boundary of the county, and alluvial clays of excellent quality will likely be found along its course. There are at present no clay industries in the county.

TROUP COUNTY

Troup county lies within the province of the Piedmont Plateau, and its rocks are granites, gneisses and schists. The residual clays derived from these rocks are of little or no value within themselves, since they have very poor plasticity and strength and contain coarse rock fragments. Alluvial clays occur along the streams and are of value as brick clays.

Trimble.—The Trimble Brick Company operates a plant at this place. The clay used is an alluvial clay along Yellowjacket Creek, and a good quality of common building brick is made. The clay is reported as from 4 to 12 feet in thickness; at the top there is a brown sandy loam 1 or 2 feet in thickness, underneath is a bluish and yellow plastic clay, while underlying the clay is sand and coarse angular quartz fragments. The full thickness of clay is not worked on account of difficulties of drainage. As in the case of nearly all alluvial clays, there is lack of uniformity and the clay varies in the amount of contained sand.

The sample of the clay which was being used for brick at the time of my visit, was tested in the laboratory with the following results: Plasticity, good; air shrinkage, average, 6.6 per cent.; drying qualities, good; tensile strength, 185 pounds per square inch.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	2.5%	pale red	soft
01	6.6%	dark red	steel hard
5	7.0%	almost black	warping

The clay is not suited for dry press or vitrified products. In practice it has fair drying qualities and works well in a stiff mud machine when the proper proportion of sandy clay is mixed with the more plastic clay. The shrinkage is not excessive.

CHATTAHOOCHEE ALLUVIUM.—Alluvial clays are known to occur along the Chattahoochee River, though they have not been developed. Such clays would be accessible to a railway line at West Point, and at the point where the Atlanta, Birmingham and Atlantic Railroad crosses the river west of La Grange. These clays would not be expected to differ markedly from the clays along the river at other points above, and should be very suitable for common building brick.

A sample of alluvial clay from the Chattahoochee west of LaGrange was sent to the Geological Survey by Mr. J. A. Morris, of Atlanta. It was a brown-yellow, micaceous sandy clay, and was evidently obtained from near the surface. It had low plasticity and a tensile strength of 62 pounds per square inch; its air shrinkage was 4.8 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	1.1%	salmon	soft, porous
03	1.9%	red	fair hardness
01	2.0%	red	almost steel hard
4	4.0%	dark red	not vitrified

The fire-shrinkage is low, due to the high sand content. The clay is well adapted for common building brick, but if mixed with a more plastic clay, such as usually underlies the surface alluvium, would make a better product.

TURNER COUNTY

The only clays known to occur in this county, are layers in the Altamaha formation. There may be places where such clays could be used to supply a local demand for brick. The following section of a hill along the Georgia, Southern and

Florida Railroad, about one-half a mile north of Worth, will indicate the geological occurrence of the Altamaha clays in the northern part of Turner county.

		Feet
1	Slope of hill, partly concealed; projecting beds of soft sandstone and conglomerate	10
2	Gray, indurated clay	2
3	Mottled clay layer	1½
4	Massive, gray sandstone	5
5	Soft, plastic clay, grading into indurated clay	5
6	Greenish or drab thin layered clay, semi-indurated	8

The lower clay is hard, and is non-plastic and mealy even when finely ground, it is semi-refractory and burns to a buff color; if mixed with the light colored plastic clay above, it would make a brick sufficiently refractory for ordinary boiler furnace use.

TWIGGS COUNTY

Alluvial clays occur along the Ocmulgee River and will probably be found suitable for common building brick, sewer pipe and drain tile. Marine clay deposits of Tertiary age lie above the kaolin beds and may be of some future value for use in connection with the white clays.

Reid Station.—The clay land of Monroe Phillips at this place has been prospected with a view of using the clay for brick manufacture. Clay occurs in the first terrace above the river or in the swamp land, and in the second terrace or cultivated land near the Southern Railway, and the two clays are designated as *swamp* clay and *field* clay.

Swamp Clay

The following are tests on two samples of the plastic clay occurring in the swamp land:

Sample	I	II
Color (raw)	bluish to yellow	yellow
Plasticity	very plastic	very plastic
Texture	fine grained	fine grained
Air-shrinkage	8.1%	7.7%
Tensile strength	105 lbs. per sq. in.	132 lbs. per sq. in.

Cone 07—		
Fire-shrinkage	1.0%	....
Color	salmon	....
Condition	not steel hard	....
Cone 05—		
Fire-shrinkage	....	2.1%
Color	....	pale red
Condition	....	not steel hard
Cone 01—		
Fire-shrinkage	6.1%	6.8%
Color	light red	light red
Condition	steel hard	steel hard
Absorption	....	14%
Cone 4—		
Fire-shrinkage	7.3%	....
Color	red	....
Condition	not vitrified	....

The clays have fair drying qualities, and show no scumming either after drying or burning.

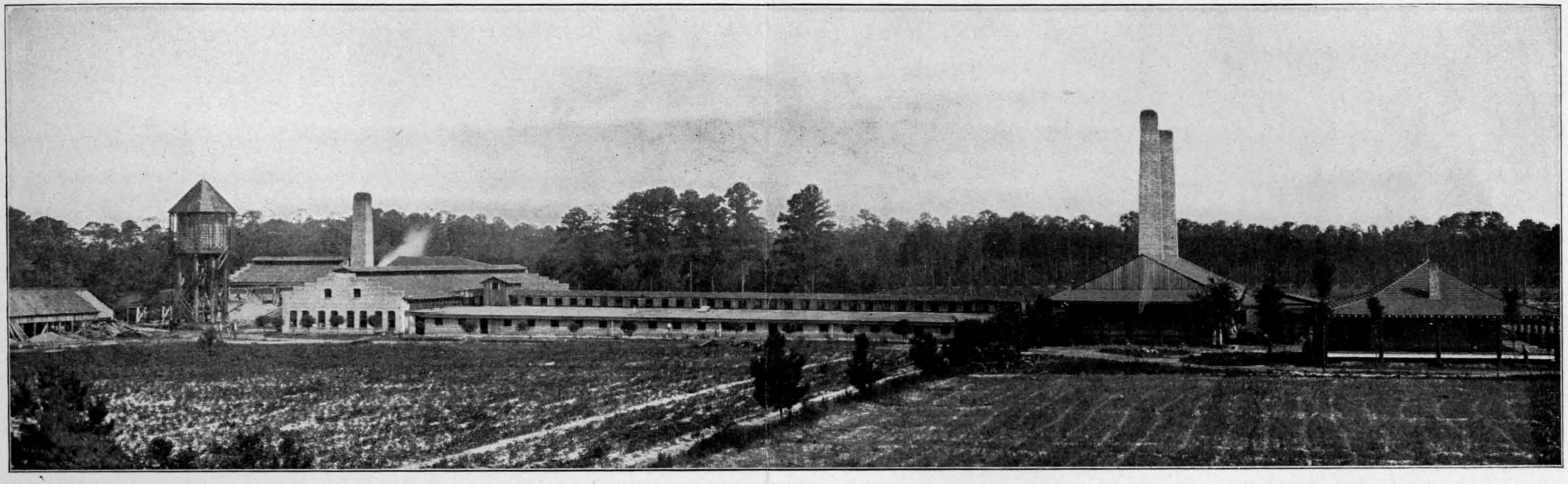
Field Clay

The sample tested was an average as near as possible of the material thrown out of a well 22 feet deep. The material is a mixture of very fine grained, gray, plastic clay and fine, micaceous sand containing iron oxide. The mixture has a yellow color. Its air shrinkage was 6.7 per cent.; tensile strength, 110 pounds per square inch. The air shrinkage is about that of the ordinary brick clay and is not excessive. Its drying qualities were fair, however, this will depend entirely upon the amount of sand, and will be good or bad accordingly, as the sand content is high or low.

Burning tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
07	1.0%	pale red	soft
05	1.6%	pale red	not steel hard
1	3.7%	red	steel hard
4	4.0%	dark red	slight checked not vitrified

The fire shrinkage is not excessive, and the bricklets showed no tendency to warp or crack at low temperatures. There is no scumming. The absorption at cone 1 was 16 per cent.; on account of the high percentage of sand, an impervious body can not be obtained at a low temperature. Should the more



GENERAL VIEW OF THE LUDOWICI-CELADON COMPANY'S "DIXIE" ROOFING TILE PLANT, LUDOWICI, LIBERTY COUNTY, GEORGIA.

plastic of the field clay be used, it would have poor drying qualities and could hardly be worked by the stiff mud process.

Mixture of Field and Swamp Clay

A mixture was made consisting of two-thirds *field* clay and one-third *swamp* clay. This mixture required 39 per cent. of water and gave good plasticity; its tensile strength was 104 pounds per square inch; air shrinkage, 7.6 per cent. Drying qualities, good.

Burning tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
07	1.3%	salmon	soft
05	1.3%	salmon	soft, not steel hard
02	3.4%	red	not steel hard
4	4.5%	dark red	not vitrified

The absorption of a bricklet at cone 02 was 15 per cent. It is evident that a brick with low absorption can not be obtained, except at high temperatures.

The upland or field clay lies adjacent to the Southern Railway. It is probably an older deposit than the swamp clay, and has an entirely different lithological aspect and was laid down under different conditions. It consists of alternating layers of sand and very fine grained plastic clay. The following records of auger borings give some idea of the occurrence of the clay:—

Hole No. 1		
Bluish and red very sandy clay	8½	feet
Bluish sandy clay	1½	"
Blue-white, putty-like clay, with yellow streaks	8	"
Quartz and mica sand, water bearing	1	"
Hole No. 2		
Soil and sand	1½	"
Bluish, stiff, tenacious sandy clay	5	"
Very sandy clay	2	"
Bluish, stiff clay	9	"
Brown and yellow micaceous clay	4	"
Hole No. 3		
Sand and sandy clay	3	"
Bluish-white and yellow stiff clay	7	"
Yellow quartz and mica sand	7	"

There is probably a workable thickness of 15 to 18 feet of the sand and clay mixture. The deposit will show considerable variations in the amount of sand. The land is clear from trees, the drainage good and the clay could be cheaply mined. Thirteen borings were made in the swamp land lying between Stone Creek and Bridge Lake, and showed a thickness of clay ranging from 4½ to 12½ feet, with an average of 7 feet. The swamp clay land is thickly wooded, and this would present a serious difficulty in the mining of the clay.

Doubtless many problems would have to be contended with, in order to make a good brick of the field clay, used alone. A mixture of this clay and the swamp clay is economically possible, and it is believed that a better product could be obtained. The swamp clay used alone is capable of making a good quality of brick, but the expense of mining it would be greater. A mixture of the swamp clay and the white fire-clays to the east, offers possibilities for sewer pipe and fire proofing.

In the Eocene formation, overlying the Cretaceous kaolins and sands, there are fuller's earth and thin layered sandy clay which may reach a thickness of 100 feet. These clays, because of their peculiar physical and chemical properties, are of scarcely any value for clay products when used alone, but may in some places be suitable for mixing with the underlying white clays of the Cretaceous. These fullers earth clays have excessive shrinkage, low specific gravity, and require a very high percentage of water to develop any plasticity.

ELEVEN-MILE POST

A sample of the sandy, shale-like clay in the railroad cut near the drying shed of the Atlanta Mining and Clay Company, 11 milepost, gave the following results in the laboratory: Plasticity, poor; very sandy; tensile strength, maximum, 210 lbs. per square inch; air shrinkage 13.9 per cent.; drying qualities, poor.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
03	1.9%	buff	soft
1	2.1%	dark buff	not steel hard
5	4.4%	dark speckled buff	not vitrified

The fire shrinkage is low and it burns without checking or cracking.

Chemical Analysis

Moisture at 100° C	8.36
Loss on ignition	7.40
Silica	60.84
(Sand	22.08)
Alumina	14.11
Ferric oxide	5.78
Manganous oxide	.26
Lime	.14
Magnesia	1.85
Sodium oxide	trace
Potassium oxide	.68
Titanium dioxide	.96
Sulphur	.00
Phosphorous pentoxide	.00
Total	100.38

The analysis does not indicate a clay of low fusibility. It will be observed that the ratio of silica to alumina is high and differs in this respect from the ordinary clay.

A mixture of three parts (by volume) of the Tertiary clay with two parts of fire clay from the mines, gave an air shrinkage of 11 per cent.; tensile strength 115 pounds per square inch. At cone 3, it showed a fire-shrinkage of 1 per cent., and burned to a dark buff, and was not vitrified at this temperature. The tests do not indicate that any mixture would be at all suitable for paving blocks or vitrified products.

Pike's Peak.—A sample of fuller's earth from the pit of the Continental Clay Company was tested as a clay. Ground to pass a 40 mesh sieve, it required 90 per cent. of water to develop any plasticity; air shrinkage 16.7 per cent.; tensile strength average, 143 pounds per square inch. It is very difficult to dry the material under any conditions without developing cracks; and when perfectly dry, it is very brittle.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	5.0%	pale buff	soft, but good strength
03	6.4%	pale buff	cracking
1	7.6%	pale buff	not steel hard
3	6.6%	faint pink	not steel hard
12	.....	....	partly fused

The material is very porous and of low specific gravity and differs from those clays with a kaolinite base in the very high percentage of water absorbed, and excessive air shrinkage. The burned strength is good, though highly porous. Such material, if at all suitable for clay products, could be used only by a dry press process.

Chemical Analysis

Moisture at 100° C	8.65
Loss on ignition	6.16
Silica	65.41
Alumina	12.84
Ferric oxide	3.57
Manganous oxide	.09
Lime	.18
Magnesia	1.84
Sodium oxide	.31
Potassium oxide	.48
Titanium dioxide	.80
Sulphur	.00
Phosphorous pentoxide	.00
Total	100.33

The following analysis and physical tests on a Tertiary fuller's earth-like clay from one mile west of Fitzpatrick, are given by Ladd[1].

Chemical analysis

Moisture	8.70
Loss on ignition	11.24
Soluble and combined silica	54.39
Sand	6.89
Alumina	14.64
Ferric oxide	0.28
Lime	7.08
Magnesia	1.71
Potash and soda	4.23
Total (less moisture)	100.46

1. Geol. Surv. of Ga. Bulletin, 6-A, p. 135.

Physical properties

Specific gravity, .90 to 1.20; not very plastic; drying shrinkage, 25 per cent.; tensile strength, 213 pounds per square inch; burning shrinkage, 6 per cent.; burned color, pale yellow; fusing point 2,426° F., about cone 10. On account of its excessive shrinkage such material can hardly be of value for clay products, either alone or mixed with other clays.

Georgia Kaolin Company Property.—A greenish or drab colored clay of Tertiary age overlies the kaolin bed in the pits of the Georgia Kaolin Company. This clay has properties in common with fullers earth, and is poorly adapted for clay products. It has high air dried strength, but an excessive shrinkage. A sample burned at cone 05 was a brownish red in color, checked badly and showed a total linear shrinkage of 20.1 per cent.

UPSON COUNTY

There are three jug potteries in the northern part of this county, 8 to 10 miles north of Thomaston. The potteries are small, several miles from railway lines, and manufacture only jugs, jars and flowerpots. Their business is purely local and the output variable, depending upon local conditions, and the manufacturing is carried on in a primitive way. The clay used is the plastic swampy clay occuring along Big Potato Creek.

Good brick clays can probably be found along Flint River in the western part of the county.

WALKER COUNTY

The shales of Walker county adapted for brick making purposes, will be discussed in another chapter of this report. Residual and alluvial clays suitable for a variety of purposes occur. The Bangor and Chickamauga limestone formations yield red and yellow residual clays which might be used for brick-making, and the residual and alluvial clays of the Conasauga shale formation have been used for stoneware.

BLOWING SPRINGS.—The American Sewerpipe Company operates a large plant at Blowing Springs, 5 miles south of Chattanooga, Tennessee; sewer pipe, drain tile and wall coping are manufactured. The clay used at Blowing Springs is an alluvial clay occurring in the valley of Chattanooga Creek. A general section of the deposit is:

1	Soil and overburden........................	2 feet
2	Yellow and bluish clay.....................	6 to 10 feet
3	Sand and gravel............................	3 " 4 "

The clay as a whole contains a variable percentage of coarse sand and is only moderately plastic, and within itself is of poor quality for sewer pipe manufacture. The deposit is of limited areal extent. A mixture of the alluvial clay and a Silurian shale occurring at Flintstone is now used. The shale burns red, vitrifies at a low temperature, but is lacking in plasticity and dried strength.

LAFAYETTE.—A small stoneware pottery has been operated here by Mr. S. N. Worthen. The clay used is an alteration product of the Conasauga shale and is yellow to bluish white, and quite plastic. It occurs along a small branch and may be partly colluvial in origin; 5 or 6 feet were exposed. A sample of the bluish-white clay tested in the laboratory of the Geological Survey, gave the following results:

The clay is almost white when dry, cream color when mixed with water; it contains a high percentage of sand is very fine grained; very plastic and has good molding qualities; its air dried tensile strength was 81 pounds per square inch; air shrinkage, 8 per cent. Burned at cone 3, it was gray in color and burned to a very dense body without warping or cracking; fire shrinkage, low, 2.7 per cent. At cone 7, it was a slightly darker color than at cone 3, vitrified, and showed no warping or cracking; fire shrinkage at this temperature, 4.1 per cent. This clay if properly burned, is suitable for a good grade of stoneware. The amount of such clay is not great, but is sufficient for the needs of a pottery.

A similar clay occurs 5 miles south of Lafayette, and a pottery was located here several years ago.

McLamore Cove.—A bluish-white plastic clay occurs on the property of James Milligan, near Cedar Grove, in McLamore Cove, lot 138(?). This clay has been mined and shipped in small quantities, but its distance from a railway line renders it of little value. The deposit is colluvial in origin, being a residual clay transported but a short distance. The clay is gray in color, very plastic and shows an air shrinkage of 6.8 per cent.; it gave a maximum air dried tensile strength of 225 pounds per square inch. At cone 7, it burned to a light gray, was vitrified and showed slight swelling; fire shrinkage was only 1 per cent., but this low shrinkage is partly accounted for by the swelling of the bricklet. The clay if located near a railroad line, would probably have a value for stoneware and terra cotta mixtures. It has low refractoriness and can hardly be classed as a fire-clay. The following analysis given by Spencer,[1] is probably of this or a similar clay in this vicinity:

Silica	69.33
Alumina	19.01
Ferric oxide	2.02
Lime	trace
Magnesia	0.87
Potash	2.16
Soda	0.18
Water (hygroscopic)	0.26
Water (combined)	6.88
Total	100.65

The following is an analysis of a greenish clay[2] from the property of J. A. Williams, lot 216, 7th district:

1. Paleozoic Group, Ga. Geol. Surv., p. 286.
2. The sample was collected by Prof. S. W. McCallie, State Geologist, and analyzed by Dr. Edgar Everhart, Chemist of the Geological Survey.

Moisture	3.87
Combined water	5.85
Hydrated silica	1.74
Combined silica	44.18
Sand	11.52
Ferric oxide	2.60
Alumina	20.68
Lime	trace
Magnesia	3.24
Soda	1.66
Potash	5.53
Total	100.87
Fluxing impurities	13.03

The clay is notable for the high percentage of potash that it contains, and the analysis indicates a clay of very low fusibility. This clay probably results from the weathering of a thin bed of shale in the Chickamauga formation and has been observed at a number of localities.

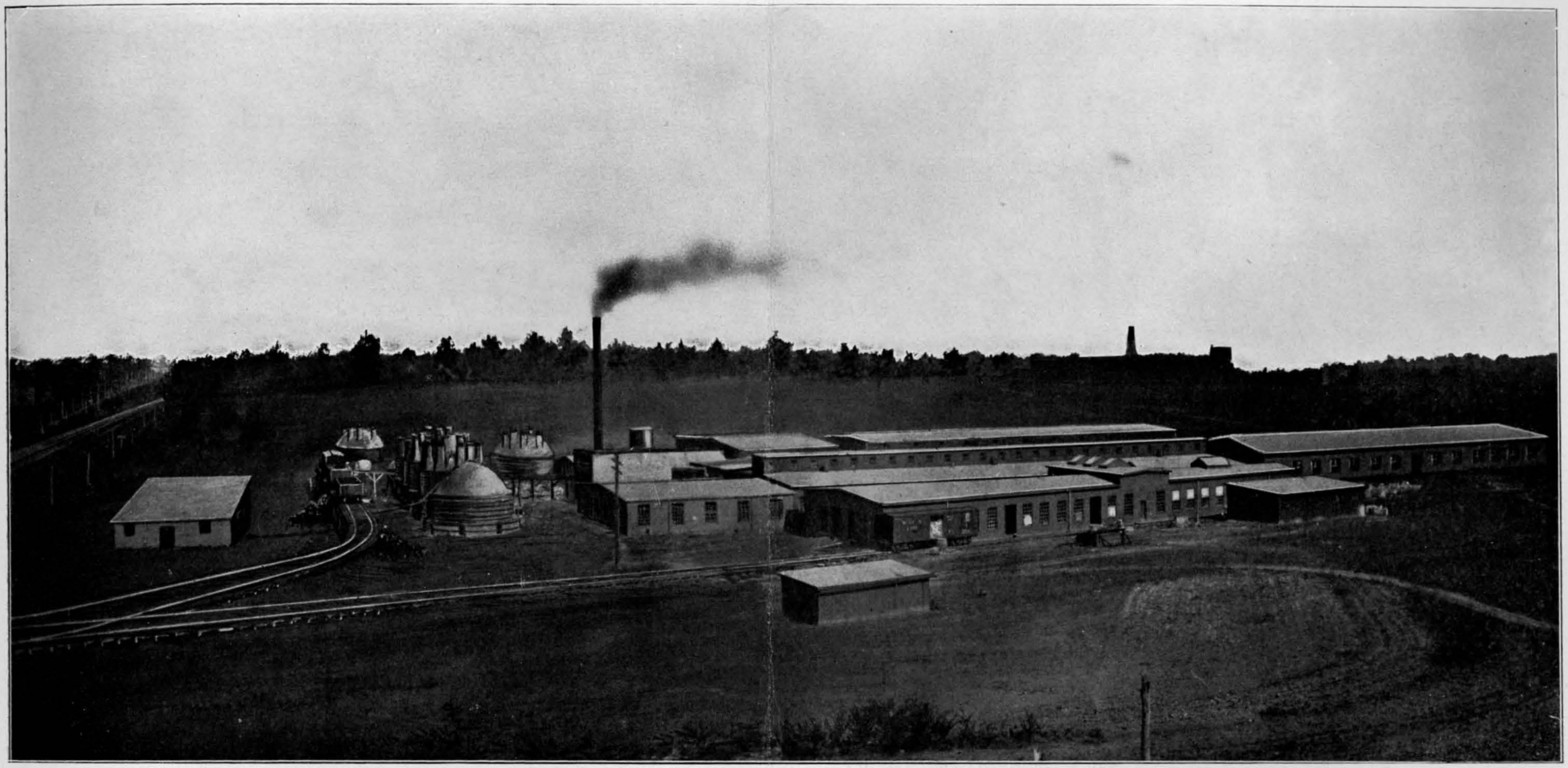
WARE COUNTY

The surface of Ware county is low, flat and covered with a mantle of sand. The southern part of the county is swamp land. There are no clay deposits known which are suitable for brick or other products. Sandy clays could possibly be found in the Altamaha formation in the northern part of the county which could be used for common building brick. If such clays are found, they may be expected to have similar properties to the clays being used at Waynesville and Odessa in Wayne county.

WASHINGTON COUNTY

Common building brick have been made near Chalker from alluvial clay along the Ogeechee River.

A small deposit of brick clay occurs on the property of Mr. C. I. Duggan, 1 mile northeast of Sandersville. This is a stiff, plastic, bluish clay containing some organic matter; it probably underlies 10 or 15 acres; the thickness of the



PLANT OF THE ATLANTA TERRA COTTA COMPANY, ATLANTA, GA.

clay has not been investigated. No tests have been made to determine its quality. It could possibly be used for common building brick for local trade.

Greenish and drab laminated and massive clays, having properties somewhat similar to the fullers earth clays of Wilkinson and Twiggs counties, occur and may reach a thickness of 100 feet or more.

WAYNE COUNTY

The clay material occurring in Wayne county which might be used for the manufacture of common building brick, consists of inter-stratified, plastic clays and red sands of the Altamaha formation, and swamp deposits of clay of Pleistocene age, occurring in the eastern part of the county along the Altamaha River. The county is entirely underlain by the Altamaha formation, though there may be only a few places where its clays occur near the surface in quantity, and accessible to railway transportation.

The Altamaha formation is a widespread clay and sand formation, deposited probably in shallow estuaries, and in Wayne county will reach a thickness of 50 to 100 feet. Common building brick are being manufactured at Odessa, 5 miles east of Jesup, and at Waynesville.

ODESSA.—The clay used at Odessa is a mixture of stiff, plastic clay and red ferruginous sand. The strata consist of alternating layers of bluish or greenish clay and sand; the clay may be in layers or laminæ, not more than an inch or two thick up to 5 or 6 feet, and the layers are quite variable in their continuity and thickness. The beds are in no place consolidated, and are easily minable. A sample of the clay mixture being used for brick at the time of my visit to the plant, gave the following results in the laboratory.

The clay is very fine grained and plastic; the sand mixed with it is coarse. A high percentage of water is required to develop good plasticity, and the air shrinkage is 12 per cent.; tensile strength, 171 pounds per square inch. The air shrinkage is less in practice since the sand grains are coarser than in the laboratory sample, which was ground to pass a 40 mesh sieve.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	1.8%	red	soft
01	4.0%	dark red	steel hard
4	4.0%	vermillion	not vitrified

The properties of the clay will vary according to the properties of sand and clay used; if the stiff, plastic clay is used alone, it is very difficult to work by any stiff mud process, its shrinkage is excessive, and drying qualities poor. The admixture of sand produces a good red color, improves the working and drying qualities, but the burned brick is porous and of low compressive strength. The best results may be obtained by adjusting the proportions of sand and clay, so that the brick may be dried and burned without serious loss from cracking, and yet not using such a large amount of sand that the product is too soft and porous. The clay should be thoroughly pugged, and burned at a temperature somewhat higher than is ordinarily employed for burning common brick.

Chemical Analysis of Odessa Clay.

Moisture at 100° C.	2.971
Loss on ignition	7.239
Silica, SiO_2	59.340
(Sand	38.120)
Alumina, Al_2O_3	17.267
Ferric oxide, Fe_2O_3	11.050
Lime, CaO	trace
Magnesia MgO	.454
Soda, Na_2O	.078
Potash, K_2O	.540
Titanium dioxide, TiO_2	1.063
Phosphorous pentoxide, P_2O_5	trace
Total	100.002

WAYNESVILLE.—The clay at Waynesville is similar in occurrence to that at Odessa, consisting of horizontal layers of plastic clay alternating with red and yellow quartz sand, containing some disseminated clay. There will be variations in the amount of clay and of sand at different places—being nearly entirely sand, or there may be clay layers several feet in thickness. The following are tests on a sample of the mixture used for brick, by the stiff mud process on an auger machine.

Physical Tests

The mixture had fair plasticity and required 38 per cent. of water to develop the maximum. The average air shrinkage was 11.5 per cent., and the average tensile strength of six briquettes tested, was 105 pounds per square inch. Under the microscope, the minerals recognizable, were the clay substance, which occurs in amorphous light colored aggregates, quartz grains of variable size, hematite and limonite, and mniute scales of muscovite mica.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	1.1%	pale red	soft, porous
1	1.5%	red	not steel hard
4	2.3%	red	not steel hard
11	3.1%	deep red	not vitrified

The fire shrinkage is low on account of the high percentage of sand, and with such a mixture as tested, a dense impervious brick can not be obtained. Notwithstanding their porosity, the brick may be very durable in a climate such as that of South Georgia. The tests do not indicate that the clay would be at all suitable for vitrified products.

Chemical Analysis of Brick Clay from Waynesville

Moisture at 100° C.	2.76
Loss on ignition	6.38
Silica	67.34
Alumina	16.18
Ferric oxide	5.27

Lime	trace
Manganous oxide	trace
Magnesia	.37
Sodium oxide	trace
Potassium oxide	.79
Titanium dioxide	1.38
Sulphur	undetermined
Phosphorous pentoxide	" "
Total	100.47

The only fluxing impurity occurring in appreciable quantity, is iron oxide, 5.2 per cent., and such a brick clay would be expected to have a high fusing point.

Other Localities.—A clay layer 4 feet thick, similar in appearance to the clay layers at Odessa and Waynesville, is exposed alongside a road passing through the property of L. R. Akin, two miles north of Mt. Pleasant.

Plastic clay is reported along the Altamaha River near the Seaboard Air Line Railroad. It is probably different in origin from the clays of the Altamaha formation, and may be worth investigating for brick and tile products. The following is an analysis of a small sample collected by the late Prof. W. S. Yeates, State Geologist. The analysis indicates a red burning clay.

Moisture	3.321
Loss on ignition	8.025
Silica SiO_2	60.716
(Silica SiO_2 soluble	4.870)
(Silica SiO_2 sand	31.560)
Alumina Al_2O_3	18.755
Ferric Oxide Fe_2O_3	6.226
Lime CaO	.578
Magnesia MgO	.618
Manganous Oxide MnO	.032
Soda Na_2O	.052
Potash K_2O	.837
Titanium dioxide TiO_2	.734
Phosphorus pentoxide P_2O_5	.046
Sulphur S	.032
Total	99.972

Plastic clay and sand in alternating layers was observed in a cut of the Atlantic Coast Line Railroad near Screven in the western part of the county.

WHITE COUNTY

There are a number of small earthenware potteries located in White county. The clay used is a plastic alluvial clay, which may be found in the valleys of almost any of the streams. No very extensive deposits occur, and the alluvial deposits are usually quite sandy; small areas of plastic clays occur, however, and are sufficient to meet the needs of the potters.

The potteries are located 15 or 18 miles from the nearest railway; their capacity is small and they are not operated continuously, but only at such times as the owners happen to have leisure from farm or other work, and when there is any special demand for the ware. The ware consists of jugs, jars, churns, and flowerpots; it is not high-grade, being in most cases poorly burned, roughly molded, and carelessly glazed. Albany slip is generally used for glazing, but an artificial glaze is sometimes made by mixing sand, clay and lime in certain proportions and grinding the mixture to a powder between buhr-stones. The clay is pugged in wooden pug mills which are operated by horse-power. The ovens or kilns are low rectangular constructions with arched tops, and are built of stone or brick, and have a capacity of 300 to 500 or 600 gallons. There is very little expense attached to the operation of one of these potteries; fuel, wood, labor and clay are obtained at a very low cost.

The following is a list of the potters: J. M. Meador, 3½ miles south of Cleveland, W. F. Dorsey and Wiley Dorsey, Leo, P. O., J. T. Dorsey, Benefit P. O. and Dorsey Bros., Mossy Creek.

A sample of alluvial clay from near Leo, used by the potters, was very plastic, air shrinkage, 8 per cent.; it showed good air dried strength and was free from coarse sand. It contained a small amount of organic matter and was dark blue in color. This clay is mixed with a yellowish, less plastic and more sandy clay for pottery manufacture.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	4%	light buff	dense body, but not steel hard
4	8%	light buff	not vitrified

There is no warping or cracking; the mixture burns to a dull gray in color.

WILCOX COUNTY

Alluvial clay occurs along the Ocmulgee River. There is a small brick yard at Abbeville using this clay. At this point it is fine grained, plastic and very stiff and tenacious, and it is very difficult to successfully work unless mixed with sand or loam. When the plastic clay is used alone, the shrinkage is excessive and it tends to split or "spall" easily after burning. It burns to a good red. In places there are limestone fragments and nodules of lime carbonate which are derived from the underlying Vicksburg-Jackson limestone formation.

The Altamaha formation underlies the greater part of the county and contains at numerous places layers of sticky, plastic clays which might be used for common building brick. These clays will likely have similar properties to the Altamaha clays decribed at other points in South Georgia. There is a good exposure showing the character of these clays in a railroad cut near the station at Abbeville.

WILKES COUNTY

Residual and alluvial clays are used to a small extent in the manufacture of common building brick. Mr. O. S. Barnett operates two small brick yards, one at Washington and one at Little River, 7 miles south of Washington, on the Georgia Railroad. Brick are made at Washington from a mixture of a residual clay derived from a granite schist and a bluish plastic clay of alluvial origin. The brick are of poor quality on account of the high percentage of coarse sand. At Little River a small deposit of alluvial clay is used, and brick of fair quality is made.

WILKINSON COUNTY

The clays in Wilkinson county available for brick and terra cotta purposes, are the white fire-clays of the Cretaceous formation, and the extensive beds of fuller's earth clays of the Tertiary (Claiborne). These latter clays overlie the white clays and may reach in places 100 feet or more in thickness; they are marine deposits, bedded or thinly laminated, gray, drab or greenish in color, of low specific gravity, soft and unctuous. They possess low plasticity and high air dried strength, but have an excessive air shrinkage. The weathered material from this formation is a greenish, sticky plastic clay, and of more value for brick purposes than the unweathered clay.

Analyses and tests of the Claiborne fullers earth clays have been given under Twiggs county.

Physical tests made by Ladd[1] on Tertiary clays in the vicinity of Gordon, showed:

	I	II	III
Air-shrinkage	25%	25%	25%
Tensile strength	....	291 lbs	300 lbs. per sq. in.
Fire-shrinkage	....	....	4%
Burned color	buff	buff	....
Fusing point	1 300°C	....	....

In Wilkinson county the clay may be in places highly calcareous, though it generally contains only a very small

1. Geol. Surv. Ga. Bulletin 6-A, p. 118.

percentage of lime. It has been suggested that a mixture of the Tertiary clay and the fire-clays of the Cretaceous might be suitable for vitrified wares. On account of certain very objectionable properties of the Tertiary clay, the writer is inclined to doubt its value for this purpose.

A sample of calcareous Tertiary clay from the property of Dr. N. T. Carswell, three miles east of McIntyre, was tested in the laboratory by the writer. The clay required a high percentage of water for mixing, and showed an air shrinkage of 12.5 per cent.; tensile strength, maximum, 300 pounds per square inch; drying qualities poor.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
03	4.1%	buff	soft
01	.....	"	slightly viscous
6	.....	.....	completely fused

A mixture consisting of two parts of the above Tertiary clay and one part of fire-clay from the same property, showed an air shrinkage of 10 per cent., and was vitrified at cone 6, burning a buff color.

A mixture consisting of equal parts of Tertiary clay and fire clay, did not vitrify until cone 12 was reached.

WORTH COUNTY

Worth county is underlain by the Altamaha formation; the surface is generally very sandy but the formation contains clay layers which might be used to supply a local demand for common building brick.

A sample of clay 1½ miles south of Poulan was tested in the laboratory. It consisted of fine grained, stiff, bluish clay, mixed with a high percentage of red and yellow quartz sand. Its air shrinkage was 12.4 per cent., tensile strength, 170 pounds per square inch.

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Brick Yard at Bainbridge, Decatur County.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
07	0.3%	light red	soft, porous
03	1.6%	dark red	good hardness
4	2.4%	" "	steel hard
13	2.5%	" "	not vitrified

Unless the clay was made sandy, it would probably give difficulty in drying. At the same time the addition of too much sand makes the burned brick soft and porous.

CHAPTER XI

SHALES OF GEORGIA

The shales of Georgia, suitable for clay products, are confined to the Paleozoic area, comprising 10 counties in the northwestern part of the State. The shales range in age from the Cambrian to the Coal Measures. The geological formations of this area have been previously discussed. There are areas of so-called ''shales'' in the Piedmont region, though this rock is highly metamorphosed, semi-crystalline and within itself is of little value for clay products.

The shales of the Paleozoic area, underlie extensive areas and belts, and are at many points accessible to railway lines. They have been greatly folded, faulted and metamorphosed, and where undecomposed by weathering agencies, are very hard and stony in character. At places they have been metamorphosed into slates. They attain great thickness; the principal shale formations varying from 500 or 600 to 2,000 or 3,000 feet.

Physical Properties.—The shales, generally, are deficient in plasticity and have low air dried strength. The samples tested by the writer varied from 20 to 75 pounds per square inch. They have low drying and burning shrinkages, burn to a hard body at low temperatures and have low vitrifying points. With a few exceptions they are high in iron oxide, and are red burning. Their slaking properties are generally poor. They can be dried and burned rapidly.

Chemical Properties.—The shales are generally highly siliceous, in some of the formations they are very sandy and grade into sandstones; analyses of samples from the localities visited show that they contain only a trace or a very small percentage of lime, though thin beds of limestone occur in them. The shales of the Cambrian and Silurian formations are generally free from carbonaceous matter, those of the Devonian and Carboniferous may be carbonaceous. The quantity of iron sulphide is rarely sufficient to be objectionable.

USES.—The shales should be found suitable for common brick, and if properly handled, will make a superior quality, notwithstanding their low plasticity. There are also localities where they give promise either alone or mixed with other clays, of being suitable for vitrified brick. They are as yet of doubtful value for other clay products.

BARTOW COUNTY

The shales of the Conasauga formation are accessible to the Louisville and Nashville Railroad, northward from Cartersville, and to the Western and Atlantic Railroad. Along the Louisville and Nashville Railroad the shales will be found interbedded with limestones and in places very siliceous and highly metamorphosed. Probably the greatest objection to their use will be their low plasticity and air-dried strength.

The shale near Adairsville does not differ greatly from that in use near Calhoun in Gordon county. The shale formation is not conspicuous, and is covered by a mantle of red or yellow soil, and is a valley forming formation. When unweathered, it will be found yellow or red, hard, and minutely jointed or fissile. It frequently alters by weathering into a bluish-gray, very plastic clay less impure than the unweathered shale. It may be found on the slopes or in the valleys of ravines and branches, and is partly residual and partly colluvial in origin. These deposits are small. A sample from the property of W. J. Newell, ½ mile north of Halls Station on the Western and Atlantic Railroad, was a bluish-gray in color, very plastic and contained a high percentage of fine silica sand. It showed an air dried tensile strength of 40 pounds per square inch, and an air shrinkage of 4.8 per cent.; it was vitrified at cone 4, and gave a fire shrinkage of 9 per cent. Such a clay might be of value in stone-ware and terra cotta mixtures.

The following are chemical analysis of Conasauga shales in Bartow county:

	I	II	III
SiO_2 sand	62.30	39.20	52.82
SiO_2 (combined)	9.30	19.40	.....
Al_2O_3	11.50	18.05	26.17
Fe_2O_3	5.59	8.31	9.46
MnO	.60	.....	.....
CaO	none	none	trace
MgO	1.30	1.55	1.08
K_2O	4.20	4.63	2.71
Na_2O	.35	.33	.20
TiO_2	1.10	.68	.....
H_2O (combined)	3.80	7.60	7.00
H_2O (hygroscopic)	.15	.40	.23
Total	100.19	100.15	99.67

I. Hydromica shale above the Etowah iron bridge south of Cartersville. Paleozoic Group, Geol. Surv. of Ga., p. 284.

II. Light red shale, one mile southwest of Cartersville. Paleozoic Group, Geol. Surv. of Ga., p. 284.

III. Shale, about two miles northwest of Cartersville. Paleozoic Group, Geol. Surv. of Ga., p. 284.

The analyses indicate red burning shales of low fusibility. The shales it will be noted, are within themselves non-calcareous. Their greatest defect is low plasticity and low air dried strength. They have not been tested on a commercial scale in Bartow county.

CATOOSA COUNTY

Rome Formation.—A belt of the Rome formation occurs in the eastern part of the county, and is crossed by the Western and Atlantic Railroad, west of Tunnel Hill. The shales of this formation are brown, red or yellow and highly siliceous. The strata are folded and crumpled. These shales do not give much promise of being of value for clay products on account of their highly siliceous character.

CONASAUGA SHALE.—A north and south belt of Conasauga shales forming Peavine Valley, occurs in the central part of the county, but is not at present accessible to railway transportation. The Conasauga here consists of yellow and greenish soft shales, interbedded with limestone. This belt is a continuation northward of the shales occupying Chattooga Valley in Walker county, and the two will be found similar.

ROCKWOOD FORMATION.—This formation, where examined, did not contain shales suitable for the use of the clay manufacturer. In White Oak Mountain near Ringgold, it consists of interbedded hard sandstones and sandy shales reaching a thickness of 1,100 to 1,300 feet[1].

FLOYD SHALES.—This formation reaches a great thickness and consists of dark colored and carbonaceous shales and thin limestone and sandstone beds. A sample of the shales of this formation from 1½ miles east of Ringgold on the Western and Atlantic Railroad gave the following results in the laboratory. When ground to pass a 40 mesh sieve, it showed fair plasticity; tensile strength, 45 pounds per square inch; air shrinkage, 4.3 per cent.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
04	6.2%	red	dense tough body
01	7.4%	dark red	completely vitrified
5	7.4%	dark red	vitrified, slight warping
13	.....	....	vesicular and warped

The shale would be suitable for common building brick, and offers a possibility for paving blocks. The tests show

1. C. W. Hayes, U. S. G. S., Ringgold Folio.

that the critical point in burning is at cone 5; above this temperature the shale would likely show warping.

The following is a chemical analysis of this shale:

Moisture at 100° C.	1.71
Loss on ignition	5.25
Silica	57.98
(Silica, sand	23.50)
Alumina	20.40
Ferric oxide	6.80
Manganous oxide	.03
Lime	.24
Magnesia	1.59
Sodium oxide	.43
Potassium oxide	4.54
Titanium dioxide	1.14
Sulphur	0.00
Phosphorous pentoxide	.00
Total	100.11

CHATTOOGA COUNTY

There are extensive areas of shales in Chattooga county. The shales of the Conasauga formation will likely be found most suitable for clay wares. The Conasauga formation occurs in two belts extending in a northeast-southwest direction across the county. The eastern belt occupies the valley in which Trion, Summerville and Lyerly are located, and which is traversed by the Central of Georgia Railway; the western belt is a continuation southwest of the Chattooga Valley of Walker county. The formation is of great thickness and consists of yellow or brown fine grained, contorted shales with occasional beds of limestone. The shale will not be adapted for brick or other purposes at some points, from the fact that it is very sandy and highly metamorphosed, and hence has lost its plasticity.

The Floyd shales occupy an extensive area east of Taylor's Ridge, and doubtless contain shales suitable for brick and other purposes, but this region is at present removed from transportation lines.

A sample of the brown, fissile shale of the Conasauga formation, from one mile east of Lyerly, was tested in the laboratory. When finely ground, it showed fair plasticity and an air dried tensile strength of 75 pounds per square inch; its drying shrinkage was 7 per cent. It burned red and to a dense body at cone 05, with a fire shrinkage of 1.8 per cent.; at cone 1, it burned into a cinder. The shale at this place gives promise of being suited for common building brick, and would burn to a dense body at a low temperature. It is minutely jointed, and weathers into small angular fragments or "shingle," and will be found uniform in composition, and the mining of it would present no special difficulties.

The following are tests on a sample of light green, micaceous altered shale from the property of B. F. Gilmer, located about 3 miles west of Lyerly at the northwest end of Dirtseller Mountain. Stratigraphically, the clay lies near the base of the Rockwood formation. A small quantity of this clay has been mined and shipped, but the writer was unable to find out for what purpose it was used. The clay doubtless occurs in large quantity, though it is rather inaccessible. It showed an air shrinkage of 8.4 per cent.; at cone 07, it burned salmon, and to a dense body, but was not vitrified; at cone 5, it was melted into a dark greenish glass.

The following is a chemical analysis of the Gilmer clay:

Moisture at 100° C.	3.288
Loss on ignition	6.030
Silica	53.083
Alumina	23.420
Ferric oxide	2.667
Lime	trace
Magnesia	3.236
Manganous oxide	trace
Sodium oxide	.780
Potassium oxide	6.990
Titanium dioxide	.368
Total	99.862

The clay contains a high percentage of potash, 6.99 per cent., and the total fluxing impurities is 13.673 per cent., and it would be expected to have a low fusing point.

No attempt is at present being made to utilize the shale deposits of this county.

DADE COUNTY

The shales of the Coal Measures of Lookout, Sand, and Fox mountains have a possible value on account of their proximity to coal deposits. The shales, however, are usually very sandy, generally inacessible, and would present difficulties in mining on account of the roughness of the topography and great thickness of overlying beds. The writer knows of no attempt to utilize them for clay wares.

The following is a section[1] of the strata at High Point, *Lot 182, 11th district*:

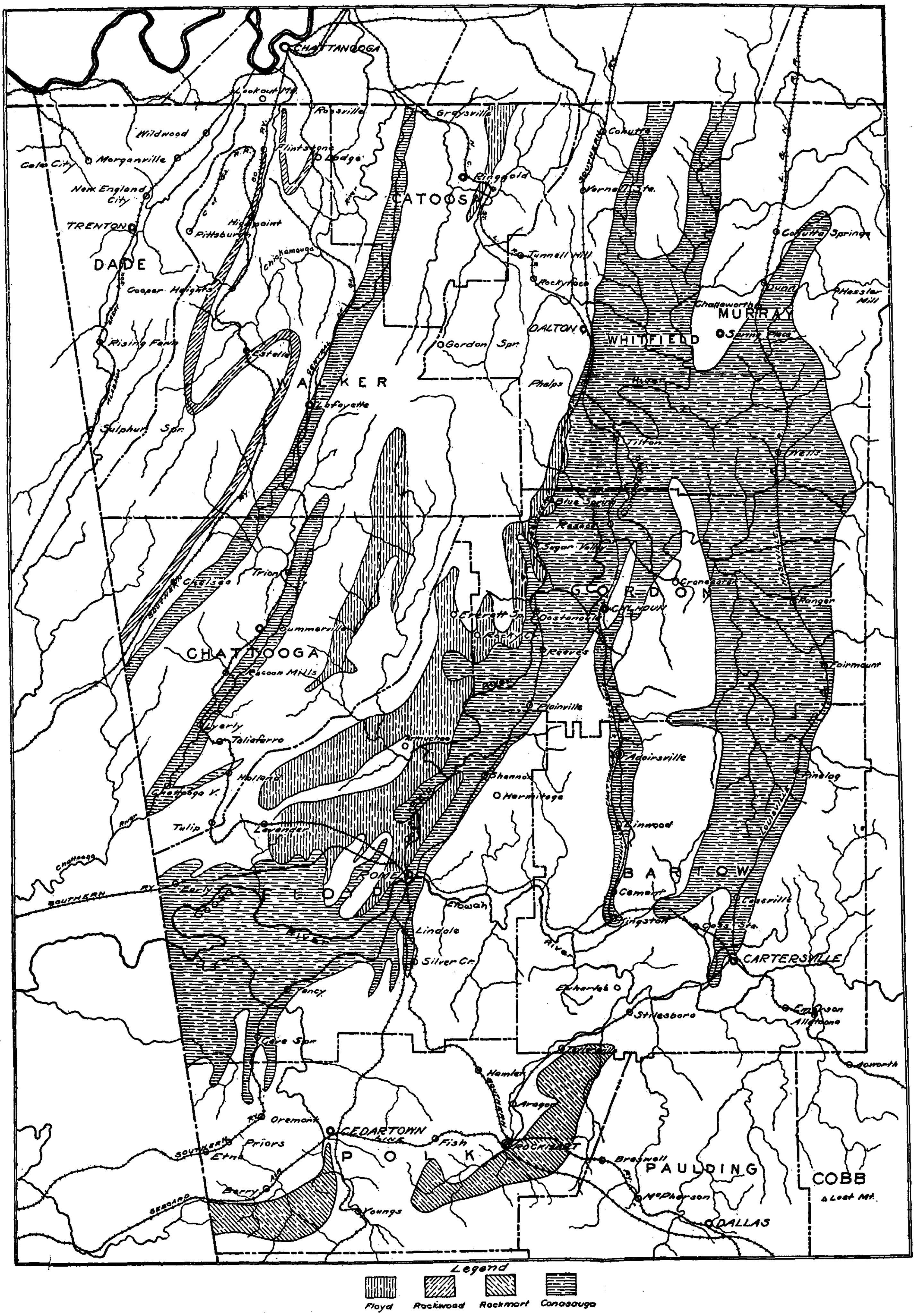
1	Conglomerate (top of mountain)	50	feet
2	Shale	3	"
3	Coal	5	" (?)
4	Shale	4	" (?)
5	Sandstone and conglomerate	70	"
6	Coal	10	inches
7	Shale	1	"
8	Coal	16	"
9	Shale	5	"
10	Coal	6	"
11	Sandstone, with casts of plants	(?)	"

Section[2] on Dr. A. T. Fricks property at the mouth of Forester's gulf:

1	Sandstone	40	feet
2	Shale	30	"
3	Coal	2 to 3	"
4	Fire clay	18	inches
5	Shale	2	feet
6	Sandstone	20	"
7	Shale	(?)	

The shales in this vicinity were observed containing iron carbonate in concretionary form.

1. S W. McCallie, Geol. Surv. of Ga. Bulletin No. 12, p. 68.
2. S. W. McCallie, Geol. Surv. of Ga. Bulletin No. 12, p. 71.



Map Showing the Distribution of the Main Shale Areas in the Paleozoic Region of Georgia.

Section[1] at Ferndale Mine, near Cole City:

1	Thin-bedded, fine-grained sandstone and mica..	variable		
2	Castle Rock coal seam..........................	14	inches	
3	Dark gray fire clay..........................	2½	feet	
4	Dark gray shale, with small flakes of mica......	27	"	
5	Dade coal seam, average thickness..............	3	"	
6	Sandy, indurated fire clay......................	2½	"	
7	Sandstone, usually thin-bedded and containing some mica	30	"	
8	Rattlesnake coal seam........................	2½	"	
9	Indurated fire clay..........................	2	"	
10	Thin-be[illegible]led sandstone	35	"	
11	Red-[illegible] coal, represented by coal smut..........	18	inches	
12	F[illegible]	2	"	
13	[illegible]dded sandstone	40	feet	
1[illegible]	[illegible]hin-bedded, partly crystalline, fossilliferous limestone	8	"	
15	Fine-grained, heavy bedded sandstone	12	"	
16	Black shale, partly exposed....................	60	"	(?)
17	Shaley sandstone, partly concealed.............	40	"	(?)
18	Concealed	80	"	
19	Bangor limestone ....(?)			

The beds of "fire-clay" mentioned in the above section, have not been investigated, and their degree of refractoriness has not been determined. Should they be found to be high grade fire-clays, the mining of them might be carried on in connection with the coal.

FLOYD COUNTY

There are extensive areas of shales in Floyd county accessible to railway lines. The shales are highly folded and often so metamorphosed that their plasticity is destroyed. The Floyd shales occupy a broad area west and northwest of Rome and may be found very suitable for clay products, since generally they are not as stony and siliceous as the shales of the Cambrian and Silurian formations.

A sample of shale from the Conasauga formation adjacent to the Southern Railway, 3 miles north of Rome, gave the following results in the laboratory: The shale was brown or yellow in color and very sandy and micaceous; it was poorly plastic and showed a tensile strength, dried, of only

1. S. W. McCallie, Geol. Surv. Ga. Bulletin No. 12, p. 92.

20 pounds per square inch. Its air shrinkage was 2.5 per cent.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	2.3%	red	steel hard
03	5.5%	dark red	vitrified
01	6.6%	dark red	vitrified
2	5.0%	almost black	warped
4	.....	....	burned to a cinder

The defect of the shale is its lack of plasticity and low air dried strength, and it could hardly be used without an admixture of a plastic clay.

Chemical Analysis of Shale, 3 Miles North of Rome

Moisture at 100° C	0.420
Loss on ignition	4.712
Silica, total	55.330
(Sand	28.030)
Alumina, Al_2O_3	22.006
Ferric oxide, Fe_2O_3	5.950
Manganous oxide, MnO	trace
Lime, CaO	.490
Magnesia, MgO	1.568
Soda, Na_2O	.821
Potash, K_2O	7.128
Titanium dioxide, TiO_2	1.104
Sulphur, S	.068
Total	99.597

The Conasauga shale is being used by the Rome Brick Company at Rome. An attempt was made to use the shale for vitrified brick, but with poor success, as it was found that the range between the vitrifying and viscosity points was small and in burning, a part of the kiln was warped and fused. It burns to a deep uniform red. It is being used, mixed with other clays, for common and pressed brick.

A small sample of the Conasauga shale east of Shannon was collected. The shale at this point is brown or yellow, soft, micaceous, minutely jointed, and breaks down into small angular chips which cover the surface. It is poorly plastic and has a low air dried tensile strength, 25 pounds per square inch. Its air shrinkage was 1.4 per cent. It burns red and to a good hardness at a low temperature. This shale is of little value for brick purposes, unless mixed with a plastic clay. However, it is quite probable that a more plastic shale can be found at other points along the Southern Railway north of Rome.

A broad area of the Conasauga formation occurs in the Coosa Valley west of Rome, and may be found to contain valuable clay shales. It is suggested that the shales might be used for paving blocks and other clay wares, when mixed with the refractory and semi-refractory clays associated with the bauxites and the iron ores of Floyd county.

GORDON COUNTY

The greater part of Gordon county is underlain by the Conasauga formation, consisting of shales and limestone. Near the surface the shales are fine grained, yellow or brown in color, becoming greenish or slate colored where unweathered, and minutely jointed, frequently breaking down into small angular chips or shingle. The shales, though frequently interbedded with limestones, are themselves non-calcareous they are not carbonaceous and are free from iron pyrites. Shales suitable for brick making purposes, may be found accessible to the Western and Atlantic, Southern, and Louisville and Nashville Railroads. The Conasauga may be deeply weathered, and the formation thus obscured; in places the shales are very hard, have a slaty or schistose appearance and then are completely lacking in plasticity.

CALHOUN.—The shale of the Conasauga formation is being used at Calhoun, by Legg Brothers Brick Company, for common and dry press building brick. It is yellow or brown to olive green in color, minutely jointed and hard. It is uniform in composition and texture, but shows variations in the degree of consolidation. A sample selected for tests in the laboratory, gave the following results: color, when ground, yellow; texture, fine grained; plasticity, poor; water required for mixing, 25 per cent.; tensile strength, average 42, maximum, 56 pounds per square inch. Its air shrinkage was 4 per cent.; it slakes in water only very slowly.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
07	2.1%	red	good hardness
05	3.1%	red	steel hard not vitrified
1	.....	dark red	viscous

In practice the shale burns to a bright uniform red; and burns into a dense body at a low temperature. Absorption tests made on a half common building brick, showed an absorption of 5.4 per cent. after three hours immersion, and showed no further increase after 48 hours. The drying qualities are good, and the shale can be worked through a stiff mud machine. There is no scumming either upon drying or after burning. The shale will make an excellent building brick, but is of doubtful value for vitrified brick. Its main defect is poor plasticity.

The Calhoun Brick Company operates a brick plant about one mile south of Calhoun. The clay used is a residual clay derived from the Conasauga shale and the decomposed shale. The weathered material is capped by a thin deposit of Lafayette red sandy loam and coarse quartz gravel. Weathering at this point may extend to a depth of 30 feet or more. The clay used at the time of the writer's visit, had excessive shrinkage, and the quartz pebbles in the Lafayette caused some difficulty.

The following is a chemical analysis of the yellow residual clay derived from the weathering of the Conasauga shale at this place:

Moisture at 100° C.	1.087
Loss on ignition	6.682
Silica	60.679
(Silica, sand	33.976)
Alumina	17.552
Ferric oxide	7.210

Lime	trace
Magnesia	.681
Manganous oxide	trace
Sodium oxide	3.615
Potassium oxide	1.982
Titanium dioxide	.736
Total	100.224

Good exposures of the Conasauga may be seen in the railroad cuts north of Resaca.

MURRAY COUNTY

The Conasauga shale adjacent to the Louisville and Nashville Railroad, will be found suitable in many places for brick purposes. A sample of the shale in the railroad cut, ½ mile north of the station at Chatsworth, gave the following results in the laboratory:

In color it is yellow to olive green; it is fine grained and lamellar; it slakes very slowly or not at all. Its plasticity is rather low, and its air dried tensile strength 40 pounds per square inch; air pressure, average, 2.6 per cent. It required 18 per cent. of water for mixing.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	3.5%	red	steel hard
01	6.0%	dark red	vitrified
1	6.5%	dark red	free from warping
4	7.0%	very dark	complete vitrification

The shale has excellent drying properties and is free from cracking and warping in burning. Its defect is low plasticity and strength. It should make an excellent common and dry press building brick, and offers possibilities for vitrified brick.

The shale at this point is overlain by a thin deposit of Tertiary or Quaternary gravel. The gravel is easily removed, and does not detract from the value of the shale.

Chemical Analysis of Chatsworth Shale.

Moisture at 100° C	1.02
Loss on ignition	5.28
Silica	57.31
(Silica, sand	24.34)
Alumina	21.52
Ferric oxide	7.65
Manganous oxide	.04
Lime	.22
Magnesia	2.47
Sodium oxide	1.29
Potassium oxide	2.70
Titanium dioxide	1.10
Sulphur	.00
Phosphorous pentoxide	.00
Total	100.60

The shale is free from objectionable lime and iron compounds.

A small brick yard is located at Chatsworth. An alluvial clay occurring in the plain traversed by Holly Creek is used.

POLK COUNTY

There are three narrow belts of the Conasauga shale in the northwestern part of the county. The shale is folded and metamorphosed, deeply weathered and obscured by residual clay and cherty from ridges of Knox dolomite.

The shales of the Rockmart slates in the southern part of the county, may in places be found suitable for brick purposes where they are partly decomposed by weathering. The slates lack plasticity and are within themselves, valueless for brick purposes.

The "Caen" stone at Rockmart and the decomposed shale at Aragon, have been previously described.

WALKER COUNTY

COAL MEASURE SHALES.—The Coal Measures attain a thickness of 1,400 to 1,500 feet, and consist of sandstone, conglomerate and shales, with thin seams of coal. The shales of Lookout Mountain are generally very sandy and interbedded with sandstones. A good exposure of argillaceous shales occurs at the high trestle of the Durham and Chickamauga, Railroad, about one mile southwest of Flintstone. The shales are for the most part inaccessible, and would probably present difficulties in mining. No attempt has been made to utilize the shales of the Coal Measures for brick or other purposes. The stratigraphy of the Coal Measures is discussed on pages 106-109.

Rockwood Formation.—The lower part of the Rockwood formation bears argillaceous shales suitable for brick purposes. The formation forms a thin band lying at the base of and paralleling Lookout and Pigeon mountains. Through folding and faulting of the strata, the formation appears at Mission Ridge on the Central of Georgia Railroad. The formation also occurs in Taylor's Ridge and Dick's Ridge in the southwestern part of the county, but this part of the county has no railway transportation.

A sample of the shale from Mission Ridge gave the following results in the laboratory: in color, it is a yellow or yellow brown; texture, fine grained; slaking, poor. It required 26 per cent. of water for mixing and developed a fair plasticity; its air dried tensile strength was 25 pounds per square inch; air shrinkage, 5 per cent.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
07	0.4%	red	good brick hardness
05	0.7%	red	not vitrified
1	.....	dark red	vitrified, but showed warping
3	.....	....	burned to a cinder

The shale used alone should be found good material for common building brick. It has been used to a small extent by the Mission Ridge Fire Brick Company. In places it becomes very ferriferous, approaching an iron ore.

Chemical Analysis of Mission Ridge Shale

Moisture at 100° C.	1.333
Loss on ignition	4.797
Silica, SiO_2 (total)	61.640
(Silica, sand	30.840)
Alumina, Al_2O_3	15.663
Ferric oxide, Fe_2O_3	8.500
Manganous oxide, MnO	trace
Lime, CaO	trace
Magnesia, MgO	1.182
Soda, Na_2O	1.799
Potash, K_2O	3.931
Titanium dioxide, TiO_2	1.242
Sulphur, S	none
Total	100.087

The following are tests on a sample of Rockwood shale from a cut on the Chattanooga Southern Railroad, near Bronco: the shale is fine grained, yellow or brown in color, rather lean and has a tensile strength of only 25 pounds per square inch. Its air shrinkage was 3.7 per cent.; it slakes only very slowly. It is free from carbonaceous matter and objectionable iron compounds as carbonate and sulphide.

Burning Tests

Cone	*Fire-shrinkage*	*Color*	*Condition*
05	3.0%	red	steel hard
03	4.6%	red	semi-vitrified
4	8.4%	very dark	completely vitrified
6	.....	....	fused
1	6.6%	dark red	vitrified

The shale burns without cracking or warping; its defect is low plasticity and strength. The partly decomposed shale would probably be superior to the unweathered shale. The laboratory tests indicate that the material might be suitable for vitrified brick.

Chemical Analysis of Bronco Shale

Moisture at 100° C.	1.62
Loss on ignition	5.36
Silica	54.48
(Silica, sand	21.70)
Alumina	22.89
Ferric oxide	7.48
Manganous oxide	.41
Lime	.22

BRICK PLANT AT TOWNSEND, McINTOSH COUNTY, GEORGIA.

Magnesia	1.40
Sodium oxide	.43
Potassium oxide	4.76
Titanium dioxide	.92
Sulphur	.03
Phosphorous pentoxide	.04
Total	100.04

The American Sewer Pipe Company has used a shale of the Rockwood formation at the plant located at Blowing Springs.

CONASAUGA SHALE.—A belt of Conasauga shale crosses the county in a northeast-southwest direction, forming Chattooga Valley. The belt has a uniform width of about 1½ miles. The formation is extensively weathered and the true character of the shale is rarely revealed at the surface. It contains thin beds of limestone and sandstone; and is folded and metamorphosed. A sample of the formation from ½ mile north of Lafayette was selected for tests. The shale is partly decomposed. It has fair plasticity and shows an air dried tensile strength of 65 pounds per square inch. Its air shrinkage was 5.8 per cent.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
05	3.8%	red	good hardness and density
1	10.1%	dark red	vitrified
4	9.5%	dark red	complete vitrification
6	.....	....	partly fused

The laboratory tests indicate that the shale at this point could be used for brick purposes.

Chemical Analysis of Lafayette Shale

Moisture at 100° C	2.00
Loss on ignition	6.59
Silica	54.31
(Sand	19.87)
Alumina	23.04
Ferric oxide	6.63
Manganous oxide	.12
Lime	.28
Magnesia	1.40
Sodium oxide	.08
Potassium oxide	4.32

Titanium dioxide	.90
Sulphur	.06
Phosphorous pentoxide	.04
Total	99.77

WHITFIELD COUNTY

TILTON.—Good exposures of the Conasauga shale occur in the bluffs of the Conasauga River near Tilton. The unweathered shale is a gray or yellow-green in color, very hard, thin bedded and siliceous. By weathering the shales are altered to red, yellow and purplish partly decomposed shales and into red and yellow clay. A sample of the unweathered shale gave the following results in the laboratory:

Its plasticity was poor; tensile strength, 44 pounds per sqaure inch; air shrinkage, 3.7 per cent. The shale is non-calcareous and is free from carbonaceous matter.

Burning Tests

Cone	*Fire-Shrinkage*	*Color*	*Condition*
04	0.9%	red	good hardness
01	5.2%	dark red	vitrified
2	.....	dark red	slightly swelling
4	.....	....	viscous

DALTON.—The red and purplish shales of the Rome formation occurring in the hill in the north part of the city, were examined, but did not give much promise of being of value for clay products on account of their stony character. The unweathered shales would certainly be wanting in plasticity.

It is believed that shales in the Conasauga formation lying north and east of Dalton could be found, which would be suitable for brick purposes. These shales will burn red and vitrify at a low temperature.

The Floyd shales occupy a small area in Redwine Cove, in the southwestern part of the county, and good brick shales may be found. The shale formation is obscured by soil and talus from the mountains.

The Conasauga weathers into red and yellow clay and in gullies and small branches the altered shale has a bluish or bluish-gray color, due probably to a leaching out of the iron oxide. The deposits in depressions and in the valleys of small streams may be quite plastic; this clay is the residual clay of the shale which has been transported by rain-water and gravity into the small branches, forming alluvial and colluvial deposits. Such deposits are usually small.

A deposit of plastic clay derived from the Conasauga shale occurs on the property of G. P. Sanders, 3 miles southeast of Dalton. A sample of this clay showed good plasticity; air-dried strength of 100 pounds per square inch; its air shrinkage was 7.1 per cent. At cone 4 it burned to a buff color and was vitrified; at cone 15, it was warped badly and was slightly viscous. At cone 18, it was partly melted. The sample tested does not contain any of the hillside clay which would burn to a darker color. The Sanders clay would probably be suitable for stoneware and terra cotta mixtures.

Chemical Analysis of Sanders Clay

Moisture at 100° C	0.478
Loss on ignition	4.201
Silica	75.381
Alumina	15.467
Ferric oxide	1.368
Lime	0.288
Magnesia	0.286
Manganous oxide	trace
Sodium oxide	.305
Potassium oxide	1.732
Titanium dioxide	.907
Sulphur	trace
Phosphorous pentoxide	none
Total	100.413

Rational Analysis

Quartz	55.349	Sand	57.55
Feldspar	2.207		
Clay substance			42.45
Total			100.000

APPENDIX A.

STATISTICS

APPENDIX A—STATISTICS.

THE FOLLOWING TABLE TAKEN FROM MINERAL RESOURCES, U. S. GEOLOGICAL SURVEY, SHOWS THE VALUE OF CLAY PRODUCTS AND CLAYS OF GEORGIA 1905, 1906 AND 1907.

PRODUCT.	1905	1906	1907
Brick:			
Common—			
Quantity	275,841,000	303,286,000	318,844,000
Value	$1,444,479	$1,783,988	$1,807,148
Average per M	$5.24	$5.88	----------
Vitrified—			
Quantity	(a)	(a)	(a)
Value	(a)	(a)	(a)
Average per M	$14.00	$13.99	$12.50
Front—			
Quantity	2,667,000	2,094,000	1,625,000
Value	$28,676	$20,747	$16,450
Average per M	$10.75	$9.91	----------
Fancy or ornamental..value	----------	----------	(a)
Fire do	$73,050	$51,310	$82,391
Stove lining do	----------	----------	(a)
Draintile do	$13,500	$12,000	$8,050
Sewer pipe do	$218,000	$221,000	$244,000
Architectural terra cotta do	(a)	(a)	(a)
Fireproofing do	(a)	(a)	(a)
Tile, not drain do	(a)	(a)	(a)
Pottery: (b)			
Earthenware and stoneware, value	$5,512	$5,345	$18,440
Yellow and Rockingham ware, value	$16,378	$14,912	$15,445
Miscellaneous value	$320,151	$291,322	$298,313
Total value	$2,119,746	$2,400,624	$2,490,237
Number of operating firms reporting	95	99	--
Rank of State	12	13	--

(a)Included in miscellaneous.
(b)Miscellaneous, 1905, value $500.

VALUE OF CLAY MINED AND SOLD, GEORGIA.

VARIETY	1905	1906	1907
Kaolin and paper clay:			
Quantity (short tons)	26,216	32,552	28,503
Value	$99,060	$141,765	$126,253
Fire clay:			
Quantity (short tons)	2,712	6,070	15,080
Value	$3,307	$14,568	$14,060
Stoneware clay:			
Quantity (short tons)	100	(a)	984
Value	$100	(a)	$1,784
Miscellaneous (value)	-----------	$417	$5,151
Total value	$102 467	$156,690	$147,248

(a)Included under miscellaneous.

APPENDIX B.

TABLE OF CHEMICAL ANALYSES

One hundred and nine of the 125 analyses collected in the following table were made by Dr. Edgar Everhart, Chemist of the Geological survey of Georgia; the other 16 are from various sources and all are given in the text of the report.

Number	LOCALITY	MATERIAL	Silica. SiO_2	Sand or Quartz.	Alumina. Al_2O_3
	Baldwin County				
1	Stevens Pottery	Fire clay	43.85	2.77	38.28
2	Stevens Pottery	Clay pebbles	44.97	2.02	38.64
	Bartow County				
3	Cartersville	Shale, undeveloped	71.60	62.30	11.50
4	Cartersville	Shale, undeveloped	58.60	39.20	18.05
5	Cartersville	Shale, undeveloped	.52	82	26.17
6	Cartersville	Alluvial brick clay	.69	18	15.43
7	Holt Bauxite Mine	Bauxitic clay	.40	16	35.80
8	Julia Bauxite Mine	Bauxitic clay	43.77	4.95	38.72
	Bibb County				
9	Macon, Bibb Brick Co	Alluvial brick clay	52.86	29.79	21.82
10	Macon, 11 miles south	Fuller's earth	70.10	4.93	11.75
	Burke County				
11	McBean, E. N. Palmer	Sandy brick clay, undeveloped.	59.89	37.21	19.82
	Camden County				
12	Woodbine, Bedell Property	Brick clay, undeveloped	70.27	55.49	13.47
13	Woodbine, Bedell Property	Brick clay, undeveloped	52.58	23.80	21.87
	Catoosa County				
14	Ringgold, 1½ miles east	Shale, undeveloped	57.98	23.50	20.40
	Chatham County				
15	Savannah, 3 miles west	Brick clay, undeveloped	64.24	29.35	15.89
	Chattooga County				
16	Lyerly, B. F. Gilmer	Shale, undeveloped	5308	10.12	23.42
	Cobb County				
17	Oakdale, J. L. Dickey	Alluvial brick clay	54.50	33.16	22.11
18	Austell	Resid'l from granite rock	48.01	16.26	32.10
	Columbia County				
19	Grovetown	Fire clay, undeveloped	60.44	26.86	25.75
20	Grovetown	Fuller's earth	68.88	1.33	7.34
21	Harlem	Sewerpipe clay	54.49	27.07	22.80
22	Harlem	Vitrified brick clay	56.92	31.89	21.18
	Coweta County				
23	Turin	Terra cotta and pottery clay	60.11	31.15	24.25
			62.19	45.00	20.00
24	Newnan, 8 miles N. E	Alluvial clay, undevel'ed			
25	Roberta	Alluv'l brick and tile clay	55.60	25.68	23.46
26	Roberta	Alluv'l brick and tile clay	59.08	40.53	20.31
27	Zenith	White Cretaceous clay	49.02	10.95	35.60
	Dade County				
28	Trenton	Red halloysite	39.96	-----	33.80

Ferric Oxide. Fe_2O_3	Lime. CaO	Magnesia. MgO	Soda. Na_2O	Potash. K_2O	Titanium Dioxide. TiO_2	Loss on Ignition.	Moisture.	MISCELLANEOUS
1.02	0.18	0.00	0.08	0.05	----	13.64	0.72	
0.64	none	0.03	trace	0.11	0.27	14.36	1.09	
5.59	0.00	1.30	0.35	4.20	1.10	3.80	0.15	Manganese dioxide 0.60.
8.31	0.00	1.55	0.33	4.63	0.68	7.60	0.40	
9.46	trace	1.08	0.20	2.71	----	7.00	0.23	
5.83	0.00	0.71	0.15	1.83	----	6.61	0.22	
trace	-----	-----	-----	-----	9.25	15.05	0.50	
1.11	0.02	0.03	0.16	0.07	2.20	13.81	0.40	Sulphur, 0.01
6.40	0.37	0.79	0.35	1.28	1.19	9.87	4.37	MnO. 0.23, S. 0.11.
2.45	0.51	1.21	0.04	0.39	0.60	6.03	7.10	P_2O_5,0.17.
6.85	-----	0.17	0.27	0.08	0.83	7.71	4.12	MnO., 0.06; P_2O_5, 0.108; Sulphur, 0.032.
3.63	0.18	0.44	0.21	0.42	0.55	5.09	5.69	Sulphur, 0.44.
5.45	0.29	0.76	0.27	0.54	0.87	16.50	-----	Sulphur, 0.053; P_2O_5, 0.07.
6.80	0.24	1.59	0.43	4.54	1.14	5.25	1.71	MnO, 0.03.
6.63	0.49	0.61	0.45	1.19	1.10	6.54	3.22	S.016, SO_3, .131, P_2O_5.021
2.66	trace	3.23	0.78	6.99	----	6.03	3.28	
8.30	0.08	0.42	0.62	2.05	1.13	9.27	1.74	S .097, MnO, 0.20.
3.01	trace	0.03	0.07	0.48	1.66	13.53	1.12	S .04.
1.27	-----	0.04	0.14	0.43	1.14	8.95	1.94	S .06, P_2O_5 0.14.
2.68	2.41	2.60	-----	-----	----	-----	12.82	P_2O_5 2.10, Undetermined 1.17.
6.55	trace	1.20	0.26	1.40	1.25	6.67	5.45	S 0.03, MnO 0.41.
7.67	0.10	1.54	0.45	1.80	1.28	5.33	3.97	MnO 0.38.
2.08	0.11	trace	0.26	1.64	0.75	8.65	2.46	
5.44	0.37	0.35	0.46	1.62	0.94	7.52	1.42	S .09, P_2O_5 .072.
5.59	trace	0.35	0.47	1.16	1.38	10.51	1.28	
5.59	0.57	0.40	0.48	2.11	0.85	7.39	2.90	S .07, P_2O_5 .024.
.84	0.04	trace	0.03	0.06	1.35	12.23	.49	
7.99	0.14	trace	-----	-----	0.04	13.40	4.99	

Number	LOCALITY	MATERIAL	Silica. SiO_2	Sand or Quartz.	Alumina. Al_2O_3
	Decatur County				
29	Attapulgus	Fuller's earth	54.11	3.62	13.03
30	Climax, Mashburn Hill	Brick clay	55.56	23.36	19.07
	DeKalb County				
31	Decatur	Alluvial clay, Everhart	47.60	12.92	27.10
	Dougherty County				
32	Albany	Brick clay, J. W. Walters	58.38	26.42	21.15
33	Albany	Brick clay, J. W. Walters	69.87	-----	15.07
34	Albany	Brick clay, S. J. Jones	53.64	-----	23.93
35	Albany	Brick clay, Warren	53.88	-----	27.57
	Effingham County				
36	Ebenezer	Brick clay	63.40	40.47	19.61
	Floyd County				
37	Rome	Brick clay, alluvium	67.80	50.80	13.82
38	Rome, 3 miles north	Shale	55.33	28.03	22.00
39	Rome, Etowah River	Brick clay, alluvium	77.60	63.30	10.90
40	Rome	Brick clay, W. T. Cheney	79.42	67.77	9.18
41	Rome	Brick clay, W. T. Cheney	72.65	51.74	11.92
42	Rome, Walters Mine	Bauxitic clay	25.83	0.06	48.22
43	Rome, Wear Mine	Bauxitic clay	37.06	0.80	40.27
44	Hermitage	Kaolin	40.40	0.80	38.60
45	Hermitage	Bauxitic clay	43.77	4.60	38.72
46	Cave Spg., Hampton Mine	Bauxitic clay	44.23	-----	38.95
47	Cave Spring, Reese Mine	Bauxitic clay	43.35	5.11	38.05
	Franklin County				
48	Canon	Brick clay	62.81	40.93	20.74
	Fulton County				
49	Chattahoochee	Shale	74.14	66.64	13.52
	Glascock County				
50	Gibson, 3 miles east	Kaolin and fire clay	47.37	0.48	38.06
51	Gibson, 3 miles east	Flint clay	56.14	17.84	28.39
	Glynn County				
52	Brunswick	Swamp clay	60.71	30.64	18.75
	Gordon County				
53	Calhoun	Residual brick clay	60.67	33.43	17.55
	Greene County				
54	Union Point	Kaolin Residual	70.31	48.04	19.71
55	Union Point	Brick clay	47.58	4.11	23.38
	Hancock County				
56	Carrs Station	Kaolin and fire clay	44.76	0.35	39.34
	Haralson County				
57	Dugdown	Metamorphic schist	61.87	37.56	20.55
58	Tallapoosa, 6 miles west	Alluvial brick clay	66.61	40.40	16.40

Ferric Oxide. Fe_2O_3	Lime. CaO	Magnesia. MgO	Soda. Na_2O	Potash. K_2O	Titanium Dioxide. TiO_2	Loss on Ignition.	Moisture.	MISCELLANEOUS
4.08	0.90	5.86	0.18	0.49	1.12	10.91	8.97	MnO. 0.11.
7.14	none	0.70	0.34	0.86	1.10	10.10	5.60	MnO, 0.4.
2.08	trace	0.35	0.15	1.40	1.34	9.70	10.70	S. 0.03
3.36	0.53	0.14	0.34	0.25	0.82	8.64	6.42	
4.30	0.32	0.08	0.30	0.33	0.79	5.87	3.44	
7.34	-----	0.39	1.06		1.20	9.55	2.89	
4.50	0.10	0.31	0.47	0.60	1.25	10.64	0.90	
6.42	0.00	0.00	0.08	0.82	1.10	6.92	1.77	
5.74	-----	0.81	0.55	2.00	1.67	7.35	0.25	
5.95	0.49	1.56	0.82	7.12	1.10	4.71	0.42	
2.25	-----	0.63	0.32	1.83	1.98	4.70	0.20	
4.25	trace	0.35	0.20	0.72	1.29	3.89	0.80	
4.25	0.34	0.43	0.32	0.80	1.15	6.60	1.72	
0.85	-----	0.18	0.15	0.19	2.53	21.77	0.24	
1.57	trace	0.18	0.11	0.15	3.68	16.59	0.29	
1.45	-----	0.30	0.02	0.09	1.95	16.35	0.35	
1.11	0.02	0.03	0.16	0.07	2.20	13.81	0.40	
0.93	0.00	0.07	0.01	0.11	1.84	13.76	0.27	
0.84	0.00	0.00	trace	trace	1.95	13.65	2.17	
5.12	0.06	0.48	0.36	0.92	0.14	7.83	1.60	
4.59	trace	0.25	0.92	2.24	0.80	3.23	0.65	MnO, 0.30
0.63	trace	trace	0.60	0.26	1.37	11.83	0.44	S. 0.04.
1.11	0.20	0.11	trace	trace	1.84	10.05	2.28	
6.22	0.57	0.61	0.05	0.83	0.73	8.02	3.32	P_2O_5 0.04, MnO . 0.03, S 0.03.
7.21	trace	0.68	3.61	1.98	.73	6.68	1.08	
0.79	0.07	trace	trace	1.68	0.09	6.22	1.21	MnO, 0.03.
8.47	4.93	3.38	1.11	0.35	0.93	7.28	2.44	S 0.13, MnO, 0.06.
1.11	0.08	0.07	0.42	0.71	1.20	12.24	0.58	
7.19	0.21	0.29	0.31	3.38	0.21	5.06	0.40	P_2O_5 0.42, MnO 0.08, S 0.07.
5.33	0.56	0.16	0.36	2.52	1.28	5.57	0.92	

Number	LOCALITY	MATERIAL	Silica. SiO_2	Sand or Quartz.	Alumina. Al_2O_3
	Houston County				
59	Fort Valley, 2 miles S. E.	Fire clay	52.17	15.55	31.33
60	Perry	Kaolin and fire clay	44.86	0.32	37.34
61	Bon Aire, Chas. Thompson	Fire clay	45.42	1.85	38.10
	Jefferson County				
62	Wrens	Flint clay	65.21	3.94	21.62
	Jones County				
63	Griswoldville, J. R. Van Buren	Kaolin and fire clay	45.53	none	37.93
64	Griswoldville, J. R. Van Buren	Kaolin and fire clay	46.34	2.15	35.47
65	Roberts	Calcareous tertiary clay	13.62	36.80	11.56
	Liberty County				
66	Ludowici	Roofing tile clay	57.30	27.16	20.02
	McDuffie County				
67	Thomson	Fire clay (undeveloped)	49.21	8.90	35.07
68	Thomson	Sandy cretaceous clay	69.08	44.25	19.25
	Montgomery County				
69	Mt. Vernon	Alluvial brick clay	50.08	12.62	26.73
	Murray County				
70	Chatsworth	Shale	57.31	24.34	21.52
	Muscogee County				
71	Columbus	Alluvium brick clay	49.41	24.96	28.64
	Newton County				
72	Starrsville	Brick clay	58.46	23.50	23.26
	Polk County				
73	Rockmart	Caen stone	64.28	30.14	21.15
74	Rockmart, 3 miles east	Terra cotta clay	67.56	40.72	21.90
75	Rockmart	Slate (not used)	58.20	-----	18.83
76	Oremont	Residual (iron ore clay)	58.88	25.98	24.73
77	Cedartown	Residual (iron ore clay)	66.20	46.10	15.41
78	Esom Hill	Bauxitic clay	44.66	-----	38.49
	Pulaski County				
79	Hawkinsville	Alluvial brick clay	57.12	26.16	23.42
	Quitman County				
80	Georgetown	Brick clay	70.64	33.85	15.64
	Randolph County				
81	Cuthbert, 8 miles north	Fire clay (undeveloped)	44.60	0.14	38.48
	Richmond County				
82	O'Connor Hill	Fire clay	43.13	0.66	36.34
83	Hephzibah	Paper kaolin	44.99	0.20	38.59
84	Belair, 3 mi. S. King Place	Fire clay	48.87	12.43	33.41

Ferric Oxide. Fe_2O_3	Lime. CaO	Magnesia. MgO	Soda. Na_2O	Potash. K_2O	Titanium Dioxide. TiO_2	Loss on Ignition.	Moisture.	MISCELLANEOUS
1.86	trace	0.14	0.24	0.25	1.58	11.03	1.04	S. 0.014.
0.56	trace	0.05	0.04	0.22	1.66	13.58	1.47	
1.41	none	trace	trace	0.10	1.10	13.59	0.49	
0.48	none	0.10	trace	trace	0.08	8.71	4.15	Soluble Silica 43.90.
0.85	.10	trace	trace	0.32	1.48	13.22	1.20	
1.02	none	0.39	0.05	0.25	1.72	12.59	1.99	
2.20	13.89	1.73	1.36	trace	----	19.41	3.64	
6.38	0.16	0.44	0.26	0.48	1.36	8.95	5.16	
1.53	none	none	0.04	0.30	1.61	12.15	0.60	
1.59	1.05	0.08	0.34	0.79	0.78	6.07	0.84	S. 0.11
5.95	0.24	0.37	0.41	0.63	1.11	10.81	4.14	
7.65	0.22	2.47	1.29	2.70	1.10	5.28	1.02	
5.58	trace	0.36	0.42	0.11	0.92	11.83	2.31	
4.62	0.19	0.36	0.52	2.27	0.46	8.45	1.60	
5.77	trace	0.09	0.92	3.62	----	4	88	
2.00	0.57	1.06	1.07	2.05	----	3.92	0.10	
-----	4.35	3.51	3	20	----	5.49	-----	FeO 5.78, S. 0.49.
2.72	trace	0.40	1.13	5.01	1.38	5.30	0.60	P_2O_5 0.24.
6.06	none	1.29	0.34	4.55	1.35	4.75	0.20	
0.54	-----	-----	-----	-----	1.49	14.08	0.54	MnO, 0.25.
5.70	trace	0.45	0.21	0.67	1.29	8.78	1.97	
3.74	trace	0.46	0.32	1.17	1.10	5.72	1.70	MnO, 0.03
1.02	0.00	0.05	0.03	1.11	1.26	13.37	1.32	
0.79	0.00	0.02	0.19	0.07	1.47	13.18	4.95	S. 0.10, P?O? 0.06
2.11	trace	0.05	0.24	0.11	1.04	12.42	0.55	P_2O_5 0.13, S. 0.02
1.11	0.00	0.09	0.31	0.41	1.65	11.53	2.69	S, 0.09.

Number	LOCALITY	MATERIAL	Silica. SiO_2	Sand or Quartz.	Alumina. Al_2O_3
	Schley County				
85	Ellaville, 7 miles S. E	White clay (undeveloped)	38.55	0.38	33.33
	Sumter County				
86	Andersonville, 6 miles E	Kaolin and fire clay	42.59	4.66	33.91
87	Andersonville, Copperas Bluff	Fire clay	43.75	0.12	36.09
	Stewart County				
88	Omaha	Alluvial brick clay	60.88	32.52	19.19
	Taylor County				
89	Butler	Paper and fire clay	47.03	2.02	37.37
	Thomas County				
90	Thomasville	Residual brick clay	50.48	10.95	31.48
	Twiggs County				
91	Dry Branch, Atl. M.& C.Co	Kaolin	45.15	0.74	38.10
92	Dry Branch, Atl. M.& C.Co	Kaolin	40.28	1.57	34.72
93	Dry Branch, Atl.M.& C.Co.	Kaolin	44.97	0.33	38.51
94	Dry Branch, I. Mandle	Kaolin	45.39	0.31	37.20
95	Dry Branch, Georgia K.Co.	Kaolin	44.76	none	38.41
96	Dry Branch, (American)	Paper clay	44.67	none	38.76
97	Dry Branch	Brick clay	60.84	22.08	14.11
98	Reids, Rico Mine	Kaolin	48.58	6.06	35.94
99	Pikes Peak	Fuller's earth	65.41	9.92	12.84
100	Fitzpatrick	Calcareous clay, undev.	54.39	6.89	14.64
101	Dry Branch	Concretionary white clay	42.83	0.48	33.39
	Walker County				
102	Lafayette	Shale	54.31	19.87	23.04
103	Bronco	Shale	54.48	21.70	22.86
104	Mission Ridge	Shale	61.64	30.84	15.66
105	Mission Ridge	Fire clay	85.00	71.18	9.72
106	McLamore Cove	Stoneware clay, undev	69.33	-----	19.01
107	Harrisburg	Residual clay	55.70	11.52	20.68
108	Durham Mines	Clay underlying coal	69.61	47.59	16.72
	Washington County				
109	Sandersville (Rollins)	Fire clay	50.12	12.68	33.09
110	Chalker	White sedimentary clay	52.30	13.85	32.88
111	Hebron	Fire clay	44.43	0.21	38.66
112	Sandersville	Brick clay	63.35	30.95	24.45
	Wayne County				
113	Odessa	Brick clay	59.34	38.12	17.26
114	Waynesville	Brick clay	67.34	42.40	16.18
	Whitfield County				
115	Dalton	Colluvial from shale	75.38	55.34	15.46
	Wilkinson County				
116	Lewiston	Paper and fire clay	44.92	1.55	39.13
117	Gordon, Z. T. Miller	Fire clay	42.72	0.82	40.42
118	Gordon, Myrick Mill	White clay, sedimentary	45.39	0.93	38.24
119	McIntyre, J. T. Hatfield	White clay (undeveloped)	45.57	0.20	38.34
120	McIntyre, Robt. Billion	Kaolin	44.92	0.20	40.04
121	McIntyre, N. T. Carswell	White clay (undeveloped)	44.22	0.45	38.40
122	McIntyre, N. T. Carswell	Hard fire clay	43.57	none	39.34
123	McIntyre, N. T. Carswell	Stained kaolin	39.88	0.26	34.36
124	Toomsboro	Fire clay (undeveloped)	46.84	4.41	37.73
125	McIntyre (Bentley)	Hard white clay	49.07	5.14	31.60

Ferric Oxide. Fe_2O^3	Lime. CaO	Magnesia. MgO	Soda. Na_2O	Potash. K_2O	Titanium Dioxide. TiO_2	Loss on Ignition.	Moisture.	MISCELLANEOUS
0.85	0.00	0.04	0.03	trace	1.47	12.14	13.38	
0.59	none	none	trace	trace	1.33	12.30	9.48	
1.59	0.25	0.13	0.29	0.03	0.82	13.64	2.61	S. 0.20.
6.23	0.21	0.83	0.49	0.33	0.91	7.78	3.48	S. 0.10.
1.15	trace	0.06	0.17	0.18	0.17	13.26	0.65	
2.72	0.00	0.09	0.04	0.21	2.53	11.91	0.86	
0.80	0.00	0.06	0.02	0.05	1.38	13.48	0.87	
0.84	0.05	0.04	trace	trace	1.15	12.39	10.72	
0.51	none	0.16	trace	trace	1.36	13.73	0.93	
0.85	0.22	0.10	trace	trace	1.54	13.32	1.69	
0.63	0.20	0.09	0.09	0.35	1.37	13.46	1.22	
0.85	trace	0.08	trace	trace	1.37	13.86	1.00	
5.78	0.14	1.85	trace	0.68	0.96	7.40	8.36	MnO 0.26.
0.85	trace	0.10	trace	0.04	1.60	12.63	0.78	
3.57	0.18	1.84	0.31	0.48	0.80	6.16	8.65	MnO 0.09.
0.28	7.08	1.71	4.23		----	11.24	8.70	
4.79	0.13	0.02	0.02	0.08	1.43	14.08	3.13	
6.63	0.28	1.40	0.08	4.32	0.90	6.59	2.00	MnO 0.12.
7.48	0.22	1.40	0.43	4.76	0.92	5.36	1.62	S .03, P_2O_5 .04, MnO .41.
8.50	trace	1.18	1.79	3.93	1.24	4.79	1.33	
1.35	trace	0.00	trace	0.44	0.28	3.16	0.34	
2.02	trace	0.87	0.18	2.10	----	6.88	0.26	
2.60	trace	3.24	1.66	5.53	----	5.85	3.87	Hydrated SiO_2 1.74.
3.38	trace	trace	0.28	1.81	1.38	5.35	1.74	S. 0.02, MnO. 0.08.
1.19	trace	0.08	trace	-----	2.26	11.82	0.96	
1.36	0.00	0.18	0.24	0.71	1.56	10.92	0.20	
0.85	none	0.03	trace	0.31	1.93	13.53	0.56	
2.03	0.05	trace	trace	trace	----	8.42	1.57	
11.05	trace	0.45	0.07	0.54	1.06	7.23	2.97	
5.27	trace	0.37	trace	0.79	1.38	6.38	2.76	
1.36	0.28	0.28	0.30	1.73	0.90	4.20	0.47	
1.05	0.40	0.17	trace	trace	----	12.98	0.99	
0.70	0.37	-----	0.83	trace	----	14.52	0.21	
1.01	0.10	trace	trace	trace	1.76	13.70	0.35	
1.02	trace	trace	trace	0.07	1.38	13.56	0.40	
0.68	0.00	0.00	0.08	0.12	1.32	13.72	0.16	
1.70	trace	trace	trace	0.28	1.48	13.47	0.90	
0.72	0.00	0.10	0.05	0.10	1.61	14.10	0.89	
11.73	0.00	0.00	trace	trace	1.49	12.42	0.58	
1.02	trace	0.13	0.02	0.08	1.26	13.01	0.43	
1.70	trace	0.82	trace	0.36	1.29	12.31	3.37	

APPENDIX C.

DIRECTORY OF GEORGIA CLAY WORKERS

BUILDING BRICK MANUFACTURERS

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
BALDWIN COUNTY				
J. W. McMillan	Milledgeville	Alluvial clay	Common and repressed brick	287
BARTOW COUNTY				
Cartersville Brick Co	Cartersville	Alluvial clay	Common brick	289
BIBB COUNTY				
Bibb Brick Co	Macon	Alluvial clay	Common, repressed and hollow brick	291
Cherokee Brick Co	Macon	Alluvial clay	Common brick	291
Standard Brick Co	Macon	Alluvial clay	Common brick	291
Charles Harris	Macon	Alluvial clay	Common brick	291
Stratton Brick Co	Macon	Alluvial clay	Common brick	291
CHATHAM COUNTY				
Benjamin Rothwell	Pooler	Sedimentary, Marine clay	Common brick	301
S. H. Collins & Son	Pooler	Sedimentary, Marine clay	Common brick	301
CLARKE COUNTY				
Georgia Brick Co	Athens	Alluvial clay	Common brick	304
Lane Brick Co	Athens	Alluvial clay	Common brick	304
Albert Wall	Athens, 5 miles West	Alluvial and residual clay	Common brick	304

BUILDING BRICK MANUFACTURERS

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
CLAY COUNTY				
F. & C. Co-operative Co	Ft. Gaines	Alluvial clay	Common brick	305
COFFEE COUNTY				
Douglas Brick Co	Douglas	Sedimentary clay (Altamaha)	Common brick	307
----------------	Barrow's Bluff	Alluvial clay	Common brick	307
DECATUR COUNTY				
L. F. Patterson	Bainbridge	Alluvial clay	Common brick	318
DOUGHERTY COUNTY				
Cruger & Pace	Albany	Alluvial clay	Common brick	320
Albany Brick Co	Albany	Alluvial clay	Common brick	320
EARLY COUNTY				
Jakin Brick Co	Jakin	Alluvial clay	Common brick	Not described
ELBERT COUNTY				
Elberton Brick Co.	Harper	Alluvial clay	Common brick	Not described

BUILDING BRICK MANUFACTURERS

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
FLOYD COUNTY				
Rome Brick Co	Rome	Shale and alluvium	Common and repressed brick	325
Morrison & Trammel	Rome	Alluvium	Common brick	324
Crucial Brick Co	Rome		Pressed brick	Not described
FRANKLIN COUNTY				
Bowers Bros	Canon	Alluvium	Common brick	327
FULTON COUNTY				
Chattahoochee Brick Co	Atlanta	Alluvium and shale	Common and repressed brick	329
Palmer Brick Co	Atlanta	Alluvium	Common brick	329
South River Brick Co	Atlanta	Shale and residual clay	Common brick	329
Capital City Brick Co	Atlanta	Alluvium	Common brick	329
GORDON COUNTY				
Legg Brothers	Calhoun	Shale	Dry pressed and common brick	395
Calhoun Brick Co	Calhoun	Residuum from shale	Common brick	396
GREENE COUNTY				
Ogeechee Brick Co	Union Point	Residual and colluvial	Common brick	331

BUILDING BRICK MANUFACTURERS

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
HALL COUNTY				
M. D. Hudson	Gainesville	Residual and alluvial	Common brick	333
Wheeler & Sons	Gainesville	Residual and alluvial	Common brick	333
Mrs. P. P. Pfeffer	Gainesville	Residual and alluvial	Common rick	333
Standard Brick Co	Oakwood	Residual and alluvial	Common brick	333
HART COUNTY				
J. D. Crawford & Son	Hartwell	Colluvial clay	Common brick	Not described
LAURENS COUNTY				
Dublin Brick Co	Dublin	Alluvium	Common brick	339
MACON COUNTY				
Oglethorpe Brick Co	Oglethorpe	Alluvium	Common brick	344
MONTGOMERY COUNTY				
Mason & Bland	Mt. Vernon	Alluvium	Common brick	345
MURRAY COUNTY				
Henley Brick Co	Chatsworth	Alluvium	Common brick	398

BUILDING BRICK MANUFACTURERS

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
MUSCOGEE COUNTY				
G. O. Berry & Son	Columbus	Alluvium	Common brick	347
Shepherd Bros	Columbus	Alluvium	Common brick	347
Muscogee Brick & Terra Cotta Co	Columbus	Alluvium	Common brick	348
NEWTON COUNTY				
Anderson Bros	Starrsville	Alluvium	Common brick	349
POLK COUNTY				
Mansfield Brick Co	Rockmart	Weathered shale	Common brick	Not described
PULASKI COUNTY				
Hawkinsville Brick Co	Hawkinsville	Alluvium	Common brick	354
----	Ainslie	Alluvium	Common brick	355
QUITMAN COUNTY				
Eufaula Brick Co	Georgetown	Alluvium	Common brick	355

BUILDING BRICK MANUFACTURERS

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
RICHMOND COUNTY				
McCoy Brick & Tile Co	Augusta	Alluvium of Savannah River	Common brick	357
Branch & Co	Augusta	Alluvium of Savannah River	Common brick	357
McKenzie Brick Co	Augusta	Alluvium of Savannah River	Common brick	357
Merry Bros	Augusta	Alluvium of Savannah River	Common brick	357
B. S. Dunbar	Augusta	Alluvium of Savannah River	ommon brick	357
Standard Brick Co	Augusta	Alluvium of Savannah River	Common brick	357
STEPHENS COUNTY				
G. W. Hitt	Toccoa	Alluvium	Common brick	Not described
STEWART COUNTY				
Chattahoochee Valley Brick Co	Omaha	Alluvium	Common brick	360
THOMAS COUNTY				
Arnold Brick Co	Thomasville	Sedimentary and residual clay	Common brick	363

BUILDING BRICK MANUFACTURERS

NAME OF FIRM	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
		TROUP COUNTY		
Trimble Brick Co	Trimble	Alluvium	Common brick	365
		TWIGGS COUNTY		
Thos. Bond	Reids	Pleistocene alluvium	Common brick	Not described
		WALKER COUNTY		
Mission Ridge Brick Co	Mission Ridge	Residual fire clay and shale	Pressed brick	280
		WAYNE COUNTY		
Waynesville Brick Co	Waynesville	Sedimentary clay of Pliocene age		377
Odessa Brick Co	Odessa	Sedimentary clay of Pliocene age		379

BUILDING BRICK MANUFACTURERS

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
SEWER PIPE AND DRAIN TILE				
H. Stevens Sons & Co	Macon	Alluvial clay		293
Stevens Bros. & Co	Stevens Pottery	Alluvial clay and fire clay		172
Georgia Vitrified Brick and Clay Co.	Campania	Fire clay and schist		308
American Sewerpipe Co.	Blowing Springs	Alluvial clay		374
FIRE CLAY PRODUCTS				
Stevens Bros. & Co	Stevens Pottery	Cretaceous fire clay	Fire brick, locomotive tiling, flue linings, etc	172
Georgia Vitrified Brick and Clay Co.	Campania	Cretaceous fire clay	Fire brick	308
Mission Ridge Brick Co.	Mission Ridge	Residual fire clay	Fire brick	280
ROOFING TILE				
Ludowici Roofing Tile Co.	Ludowici	Pleistocene alluvium	Plain, and interlocking tile (unglazed)	340
TERRA COTTA				
Atlanta Terra Cotta Co	East Point	See text of report	Architectural terra cotta	329

POTTERY

FIRM NAME	LOCATION OF PLANT	MATERIAL USED	PRODUCTS	PAGE IN REPORT
Magnesia Stoneware Co	East Point	Fire clay and plastic alluvial clays	Jugs	329
J. D. Brewer	Bogart	Plastic alluvial clay	Common earthenware	381
J. M. Meador	Cleveland	Plastic alluvial clay	Common earthenware	381
W. F. Dorsey	Leo	Plastic alluvial clay	Common earthenware	381
Dorsey Bros	Mossy Creek	Plastic alluvial clay	Common earthenware	381
Puckett Bros	Oakwood	Plastic alluvial clay	Common earthenware	333
S. N. Worthen	Lafayette	Residual clay from shale	Common earthenware	374
Emmet Merritt	Lizella	Stream alluvial and fire clay	Common earthenware	219
J. E. Bryant, Jr	Fort Valley	Stream alluvial and fire clay	Common earthenware	219
C. J. Beecham	Knoxville	Stream alluvial and fire clay	Common earthenware	219
W. F. Shephard	Cartersville	Plastic stream mud	Common earthenware	290
C. C. Brumbeloe	Meansville	Plastic stream mud	Common earthenware	373
W. R. Brumbeloe	Thomaston	Plastic stream mud	Common earthenware	373
J. W. Beecham	Knoxville	Alluvial and fire clay	Common earthenware	219
Monroe Hortley	Knoxville	Alluvial and fire clay	Common earthenware	219
James Yawn	Knoxville	Alluvial and fire clay	Common earthenware	219
Chas. Avery	Knoxville	Alluvial and fire clay	Common earthenware	219

CLAY MINERS

FIRM NAME	LOCATION OF PLANT	MATERIAL MINED	PRODUCTS	PAGE IN REPORT
Georgia Kaolin Co	Dry Branch	Cretaceous, sedimentary clays	Kaolins (paper and pottery) fire clays	125
Atlanta Mining & Clay Co	Dry Branch	Cretaceous, sedimentary clays	Kaolins (paper and pottery) fire clays	130
I. Mandle & Co	Dry Branch	Cretaceous, sedimentary clays	Pottery kaolin	142
American Clay Co	Dry Branch	Cretaceous, sedimentary clays	Paper Clay	138
Albion Kaolin Co	Hephzibah	Cretaceous, sedimentary clays	Paper clay	186
J. R. Wimberley	Perry	Cretaceous, sedimentary clays	Paper clay and fire clay	209
J. R. Van Buren	Griswoldville	Cretaceous, sedimentary clays	Fire clay	154
J. W. Huckobee	Lewiston	Cretaceous, sedimentary clays	Fire Clay	159
J. D. Carr	Carr's Station	Cretaceous, sedimentary clays	Fire clay	204

APPENDIX D

THE BAUXITE OF WILKINSON COUNTY, GEORGIA

While making a study of the white clays of the Cretaceous formation of Georgia, the writer observed a concretionary clay-like rock in the northern part of Wilkinson county, which upon being analyzed was found to be bauxite. Since the announcement of the discovery a number of other occurrences have been observed, but little prospecting has been done or attempt been made to determine the commercial importance of the deposits. At the point of discovery, however, the ore is known to be in commercial quantity. Aside from the commercial aspect, the deposits seem to be in origin unlike those of any other locality described, and may be of much scientific interest. The bauxite is closely associated with white clay beds and it seems not improbable that the bauxite is a chemical alteration of the clay.

The deposits are in no way connected with those of the Georgia-Alabama field. The bauxite occurs in Central Georgia, near the northern margin of the Coastal Plain, 20 to 30 miles east of the city of Macon, and about 150 miles distant from the Georgia-Alabama deposits. The rocks of the region are of lower Cretaceous, Tertiary and Pleistocene ages, and rest upon a floor of igneous and metamorphic rocks which are exposed a few miles to the northward. The bauxite as far as observed lies near the contact between the lower Cretaceous (Tuscaloosa formation) and the Tertiary (Claiborne formation). The strata are for the most part unconsolidated sands and clays, having no pronounced structural features; the beds lie almost horizontal, having only a slight dip southward; the slope of the crystalline floor near the Fall Line is 50 to 75 feet per mile.

Geology

The crystalline rocks immediately north of the bauxite occurrences, consist of coarse grained highly feldspathic granite, deeply weathered, schists of uncertain origin and trap dikes supposed to be the equivalents of the Triassic trap dikes of the Atlantic coast. The dikes are small and are typical diabase, consisting principally of plagioclase and augite with accessory olivine and magnetite. It is not believed that these rocks have any direct bearing upon the origin of the bauxite and their description will not be entered into in detail.

The Lower Cretaceous or Tuscaloosa formation, lies upon the eroded crystallines and consists for the most part of unconsolidated sands and clays. The rock of the formation was probably deposited in fresh or off-shore, inland, bodies of water, since it gives no evidence of marine conditions. The lower part consists of loose and coarse grained clayey sand characteristically crossbedded and gray or red in color. It contains lenticular beds of white clay, but these lenses are of small extent, vary in texture and grade into sand abruptly. In the upper part of the formation there are remarkable beds of white and stained clays approaching kaolins in composition, which may reach a thickness of 30 feet. The clays are massive bedded, not laminated, both soft and hard, and contain only a small percentage of sandy impurities. The bauxite is closely associated with these white clay beds. The Tuscaloosa formation probably reaches a thickness of 500 or 600 feet. It is largely obscured by overlying formations and good exposures are obtained only where stream erosion has been active. The sands consist of quartz and mica principally, with very small amounts of other minerals common to the igneous rocks of the Piedmont Plateau. As above mentioned the clays are quite pure and approach kaolins in composition.

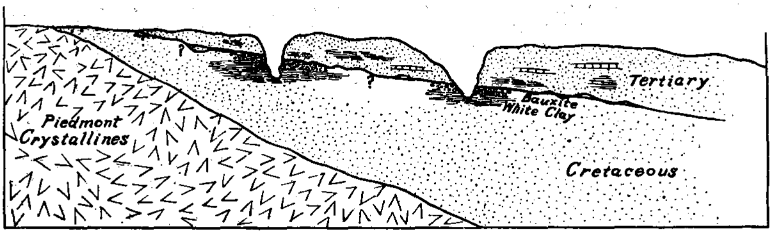


Fig. 13.—Generalized North-South Section Showing the Geological Position of the Wilkinson County Bauxite

Middle Eocene (Claiborne formation) sands and clays unconformably overlie the Cretaceous and reach a thickness of 150 to 200 feet. The Tertiary presents a distinct lithologic difference from the Cretaceous. It consists of highly ferruginous and argillaceous sands (unconsolidated) laminated impure clays in the nature of fuller's earth and patches of limestone and quartzite. The lower part of the formation, where it is in contact with the Cretaceous, frequently contains large boulders, and small pellets of white clay, evidently torn from the white clay beds of the Cretaceous. The Tertiary here is a marine deposit and contains abundant remains of marine life.

The clay of the formation is laminated and thinly bedded, and is of variable thickness and continuity; it may reach a thickness of a 100 feet or more. It often occurs as thin leaves or laminae a half or an inch thick, with thin sand partings. The clays are gray, greenish or drab in color; they are rarely stony in appearance and not sufficiently consolidated to be termed shales; they are frequently calcareous and contain hard nodular calcareous layers. The clay is distinguished by its low specific gravity and peculiar physical properties, being highly porous and having some of the properties of a fuller's earth. A hand specimen is soft, unctuous, generally free from coarse sand, and breaks with a smooth conchoidal fracture. Microscopic examinations of these clays reveal quartz, muscovite mica, feldspar, magnetite, besides the clay substance. The clays where weathered are often tough and waxy and lines of stratification are obscured. The composition of the clays is shown by the following analyses:

	I	II	III
Moisture	0.00	3.64	.....
Loss of ignition	11.24	15.41	6.74
Silica SiO_2 (total)	61.28	50.42	71.61
(Silica SiO_2 (sand)	6.89	36.80	.....)
Alumina Al_2O_3	14.64	11.56	14.06
Ferric oxide Fe_2O_3	0.28	2.20	3.91
Lime CaO	7.08	13.89	.24
Magnesia MgO	1.71	1.73	2.01
Sodium oxide Na_2O / Potassium oxide K_2O	4.23	1.36	.34
Titanium dioxide TiO_2	.....	.....	.88
Total	100.46	100.21	99.79

The sand of the Claiborne is generally highly ferruginous; at the surface it is a bright red in color, but where unweathered may be gray, yellow or purplish. The sand is largely quartz, with some mica. It is often argillaceous, containing clay in thin laminae. The sand of the formation near the contact with the Cretaceous is clayey and yellowish green in appearance often suggesting the presence of glauconite.

A mantle of loose gray sand, varying from nothing to 5 or 6 feet in thickness overlies the Cretaceous and Tertiary formations. It is probably of Pleistocene age and is similar to the gray Columbia sand, which overspreads the entire Coastal Plain.

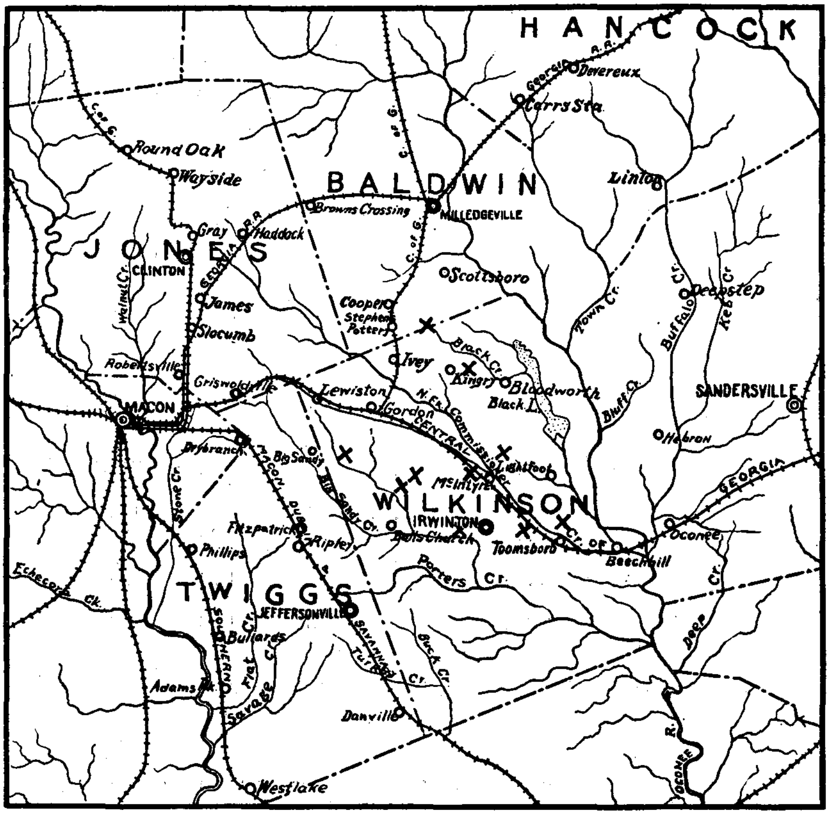


Fig. 14—Map of a portion of Central Georgia, showing the location of the Wilkinson County Bauxite Field. X Bauxite Outcrops.

Bauxite

The bauxite as far as has been observed lies near the contact of the Cretaceous and Tertiary formations and is always contiguous to white clay beds. It lies in the form of beds directly upon the clays of the Cretaceous and has been observed as bowlders scattered in the soil, together with fragments of pitted and concretionary clay. The bauxite beds have been observed with a thickness of 10 feet; there is no evidence of stratification.

The bauxite is generally pisolitic or concretionary, but may in some cases be amorphous and without concretionary structure. It may be composed almost entirely of pisolites about the size of a pea, or may be dense, halloysitic and even flinty. in appearance with only a few scattered concretions imbedded in the mass. The concretions vary in size from oolites to balls one inch in diameter. They, nearly in all cases, have a hard, concentric outer rim or shell enclosing a detached ball of softer, more earthly material. The pisolites may be hollow or have simply a spongy skeleton of the interior remaining, while in other cases the whole pisolite is hard and flinty, the outer rim differing slightly in appearance from the interior. In some specimens, there are small cavities lined with a soft yellow, incrustation which may be gibbsite.

In one locality the ore seems to be made up of irregular shaped and round pebbles varying from $\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter; the interstices between the pebbles are composed of a horn-like translucent bauxite and an altered sand in which free quartz and occasionally mica may be detected. The pebbles are smooth and appear to have been water-worn before their deposition. Most of these pebbles are amorphous and do not have a concretionary structure. They are highly ferruginous, the iron appearing to be a replacement of the bauxite in place.

The bauxite varies in color from almost white and cream color to a bright red. It is generally hard—no soft, granular, clay-like varieties have yet been observed.

The following analyses, made by Dr. Edgar Everhart, Chemist of the Geological Survey of Georgia, show the composition of the ore:

ANALYSES OF WILKINSON COUNTY BAUXITE

No.	Al_2O_3	Fe_2O_3	SiO_2	TiO_2	H_2O	Moisture	Undetermined
1	52.92	7.66	10.17	2.30	26.55	.35	....
2	57.58	.96	9.38	2.76	29.12	.35	....
3	41.97	18.24	17.50	2.65	16.83	2.65	.16
4	57.36	1.94	.90	3.65	32.44	.67	3.04
5	42.73	14.99	15.57	1.84	20.29	2.79	....
6	61.77	1.67	.90	2.26	31.77	.95	....
7	60.64	1.33	2.30	2.00	30.58	2.79	....
8	61.00	1.94	.74	2.66	32.93	.46	....
9	60.54	1.94	1.96	2.01	32.51	.35	....
10	62.46	.81	4.72	.23	31.03	...	....
11	49.94	9.32	8.32	1.98	27.24	1.94	....
12	39.92	16.84	20.00	1.47	19.52	1.25	....
13	60.55	1.89	2.12	1.96	32.97	...	....
14	61.52	1.70	1.18	2.70	32.76	...	.14

In the analyses of the purest bauxite, the ratio of alumina to water approaches most closely that of the tri-hydrate of alumina, gibbsite. The iron oxide exists as a mechanical impurity or as a replacement of the bauxite; the silica exists in the form of clay as a mechanical impurity, and as an opaline, soluble silica.

ORIGIN OF THE BAUXITE

The origin of the bauxite is obscure. The geological conditions under which it formed were evidently different from those of the Georgia-Alabama and the Arkansas districts, and it is not believed that the theories advanced in explanation of the latter deposits are applicable to the Wilkinson county bauxite.

The close association of the Wilkinson county bauxite with the white clays and sedimentary kaolins of the Cretaceous at once suggests these clays as the source of the alumina of the bauxite. The facts collected in the field and chemical analyses favor most strongly the idea that the bauxite has resulted from a chemical alteration in place of pure clays. The following analyses suggest a gradation from clay to bauxite:

Analyses Showing Gradation of Clay to Bauxite

	I	II	III	IV	V	VI
Moisture	.35	0.89	0.78	....	.33	....
Combined water H_2O...	13.70	14.10	14.54	18.12	29.10	32.97
Alumina Al_2O_3	38.24	39.34	40.91	43.50	55.21	60.55
Silica SiO_2 (total)	45.39	43.57a	41.21b	33.34	12.40	2.12
(Silica SiO_2 (sand)	.93	1.12	5.63	.....	.....	.....)
Ferric oxide Fe_2O_3	1.01	.72	.81	1.89	.96	1.89
Titanium dioxide TiO_2..	1.76	1.61	1.52	1.53	2.15	1.96
Lime CaO	0.10	none	.....	.....	.....	.....
Magnesia MgO	trace	0.10	0.12	.....	.....	.....
Sodium oxide Na_2O	trace	0.05	0.04	.....	.....	.....
Potassium oxide K_2O ...	trace	0.10	0.24	.....	.....	.....
Total...........	100.55	100.48	100.17	98.38	100.15	99.49

(a) Soluble silica, 5.28%
(b) Soluble silica, 4.82%
Analyses by Dr. Edgar Everhart.

All of the samples are from Wilkinson county. No. 1 is an unaltered white clay, and is representative of extensive beds which occur in Wilkinson and adjoining counties. Nos. II and III are semi-indurated clays, which contain coarse nodules and concretions and have the appearance of bauxite, Nos. IV and V show a further decrease in silica, and No. VI is a relatively pure bauxite. The silica in Nos. IV, V and VI, exists mainly in combination with alumina as clay and partly as soluble silica, but does not exist in appreciable percentages as free silica or quartz sand.

In the field, samples of clay may be observed which in their physical appearance suggest an alteration process to bauxite. These clays are semi-hard, mealy and have lost some of their plasticity; they contain both nodules without concretionary structure and concretions, giving the whole the appearance of bauxite. Analyses show, however, not only a small excess of alumina over silica, but also show that a part of the silica exists in a soluble form. These clays form the upper part (in contact with the Tertiary) of massive, non-laminated, white clay beds which may reach a thickness of 30 feet; the lower part of these beds is structureless, soft clay, but there is no sharp line between the two. Frequently the nodules and concretions weather out of the clay, giving the clay a pitted and honey-combed appearance. At one locality irregular shaped nodules of bauxite were scattered through the soil, and were evidently derived by a weathering out process, probably from a bauxite clay. Concretions have been observed, which though possessing a distinct concentric structure seem to be kaolin. It is not unlikely that these concretions upon closer examination will show a high percentage of soluble silica, or silica not in combination with alumina as in kaolin. Specimens may also be obtained which are part clay and part bauxite, and which are not simply mechanical mixtures which may have resulted after the formation of the bauxite.

Bowlders of relatively pure bauxite together with fragments of pitted clay, are very often found in the soil lying upon the beds of honey-combed or pitted kaolins.

Assuming then that the bauxite was derived by a chemical process from the clay, what was the chemical solvent which affected the change, and under what conditions? The manner in which a relatively pure clay or kaolin could be decomposed with the formation of bauxite confessedly offers a difficult problem. The most satisfactory conclusion which the writer can come to, considering the limited opportunity of collecting facts, since the bauxite is as yet wholly undeveloped, is that the kaolin and other clay may have been altered by circulating highly alkaline waters of meteoric origin. The alkaline carbonates as sodium carbonate or bicarbonate, $NaHCO_3$, may have been formed by the action of carbonic acid on alkaline silicates or other alkaline salts in the overlying Tertiary, and being taken into solution by circulating waters issued as springs near the contact of the Tertiary with the impervious white clays of the underlying Cretaceous. The action of the sodium carbonate on the kaolin would result in the desilication of the kaolin with the formation of a sodium silicate, leaving an aluminous hydroxide in a gelatinous or colloidal condition. The action of alkaline carbonates upon the clay would take place more readily were the waters carrying them in solution, heated.

The conclusion is that the bauxite has been derived by the action of a decomposing agent upon the clay, whatever this chemical may have been, or its source. Certainly, this chemical must have been a more powerful solvent than carbonic acid, and the alteration was effected by other than simple weathering agencies. The possibility of thermal waters derived from the nearby igneous rocks of the Piedmont Plateau, or those underlying the sediments, effecting the alteration, was considered, but under the geological conditions this seems to have little evidence in its favor. Waters carrying sulphuric acid would be capable of decomposing the clay, but the source of the acid would be difficult to explain, since, so far as known, the overlying Tertiary and the Cretaceous contain no appreciable amounts of sulphur compounds.

Description of Bauxite Occurrences

A number of occurrences of bauxite in widely separated localities has been reported, but no development work has yet been undertaken and scarcely any prospecting has been done. Until the localities which are known are intelligently prospected, the commercial importance of the deposits will remain in doubt.

Parker-Honeycutt Locality.—This occurrence is located about 3 miles northeast of McIntyre, and 1½ miles north of the 159 mile-post on the Central of Georgia Railway. Ore occurs on the property of Mrs. W. R. Parker, J. R. Honeycutt, W. E. Honeycutt, and James Daniel. These properties are adjoining, and the geological occurrence of the bauxite is the same on each of the properties, and the outcrops appear to be at about the same level. The ore varies, however, in its physical appearance and in quality. The bauxite occurs in blanket form or in beds, and rests upon clay beds presumably of Cretaceous age, and is overlain and in contact with sands and clays of the Middle Eocene age (Claiborne formation). The mineral is pisolitic or concretionary, locally called "honeycomb" rock, and varies in color from almost white to a dark red.

On the property of Mrs. W. R. Parker, there is a good natural exposure of the ore, on the west side of Dry Branch, and about 15 feet above the level of the creek. The bauxite is abundantly strewn over the surface in the form of bowlders and fragments, and the bed is known to reach a thickness of 10 feet. The bed is underlain by a soft, pink and highly stained, structureless clay, the thickness of which certainly exceeds 10 feet. Overlying the bauxite bed is unconsolidated ferruginous sand, probably of Tertiary age. This sand, together with a superficial loose sand a few feet in thickness, constitutes the overburden of the bauxite. From the bauxite outcrop, there is a gradual increase to the top of the ridge to the west, which has an elevation of 75 to 100 feet above the creek. There are no exposures by which it can be determined whether there is an abrupt change from bauxite to clay or whether there is a transition. The bauxite here is white, cream colored and yellow, and entirely pisolitic. It undergoes bleaching and hardens slightly upon exposure to the atmosphere. The following is an analysis by Dr. Edgar Everhart of a surface sample:

Alumina, Al_2O_3	57.58
Silica, SiO_2	9.38
Ferric oxide, Fe_2O_3	.96
Titanium dioxide, TiO_2	2.76
Combined water, H_2O	29.12
Moisture	.35
Total	100.15

The westward extent of the bed, or the distance to which it extends into the hill, has not been determined. A well sunk at the residence of W. R. Parker, ¼ mile west of the outcrop, reached the white clay bed of the Cretaceous, but as far as can be ascertained no bauxite was found. The bed seems to disappear to the northward. The quantity of the ore here is sufficient, however, to justify exploitation.

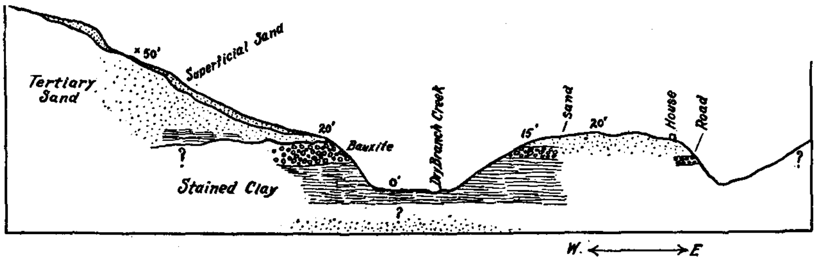


Fig. 15.—Cross-section of the Parker-Honeycutt Bauxite Properties

A continuation of the Parker bed occurs on the Daniel property adjoining on the south. It is similar in appearance. It has not been prospected, but the surface outcrop indicates that a commercial quantity of the ore exists.

The bauxite is prominently exposed on the property of J. R. Honeycutt on the east side of Dry Branch and adjoining the Parker property. The bauxite differs from that on the west side of the branch in that it is highly ferruginous and red in color. It consists of small concretions of pisolites imbedded in an earthy and halloysitic matrix. The underlying clay is soft and mottled red and white, or is a solid red. The bauxite is known to reach a thickness of 4 feet and may exceed or be less than this thickness. It occupies a small knoll and probably underlies 4 or 5 acres. The overburden is inconsiderable. Analyses made upon samples collected at the surface show the ore to be low grade.

Alumina, Al_2O_3	52.92	49.94
Silica, SiO_2	10.17	8.32
Ferric oxide, Fe_2O_3	7.66	9.32
Titanium dioxide, TiO_2	2.30	1.98
Combined water, H_2O	26.55	27.24
Moisture	.35	1.94
Total	99.95	98.74

Analyses by Dr. Edgar Everhart.

Analysis of the underlying red clay showed:

Alumina, Al_2O_3	30.08
Silica, SiO_2	37.92
Ferric oxide, Fe_2O_3	17.46
Titanium dioxide, TiO_2	1.56
Combined water, H_2O	12.06
Moisture	.55
Total	99.63

A red, ferruginous bauxite occurs on the property of W. E. Honeycutt, adjoining the Daniel and J. R. Honeycutt places on the south. The ore was found in sinking a well and is also exposed naturally. No prospecting has been done to determine the extent of the deposit.

J. U. Parker's Property.—This location is 5 miles north of McIntyre, on lot 172, 4th district, Wilkinson county. Large bowlders of bauxite are abundantly scattered over small knolls on this property. These bowlders are drab colored, very hard and flinty, with only scattered pisolites. They appear to be a residue of weathering and erosion and are not in place, and were probably derived from a bed lying at a higher elevation. Evidence of such bed, overlying a white clay or kaolin, is found in scattered concretions lying along the side of a Tertiary ridge.

The bauxite here is high grade, and justifies further prospecting.

The following is an analysis of the J. U. Parker bauxite:

Alumina, Al_2O_3	60.55
Silica, SiO_2	2.12
Ferric oxide, Fe_2O_3	1.89
Titanium dioxide, TiO_2	1.96
Combined water, H_2O	32.97
Total	99.49

McIntyre.—Bowlders of bauxite occur on the property of Dr. W. A. Parker near McIntyre station. The bowlders are scattered over a cultivated field, and have been turned up in plowing. The bauxite does not seem to be in place and is probably residual. Beds of white, pitted clay are exposed, which have been mistaken for bauxite. The ore is of good quality, but there is very little surface indication of any large deposit.

Holleman Property.—Scattered bowlders of bauxite have been found on the Holleman property, 3 miles west of McIntyre. A white clay, semi-indurated, which has been quarried out for building purposes, occurs here, and the bauxite fragments lie in the slope beneath this clay bed. It seems probable that they are erosion remnants of a bed which once existed above the clay bed. The ore here shows 60 per cent. alumina.

On the same property on the south side of the Central of Georgia Railway track, fragments of a highly ferruginous, pebbly bauxite are observed in the soil. Search in the ridge, above the fragments, failed to reveal any bauxite bed.

R. W. Adkins' Property.—This property is located about 3 miles east of McIntyre, on the south side of the railroad track. Only scattered fragments of bauxite have been found. These are closely associated with beds of white semi-indurated clays or "chalk." Thus far no minable quantity of bauxite has been found, and if such exists it may be expected at a higher level than the scattered fragments, which are underlain by clay. This statement is based upon my field observations so far as conducted which are, that the bauxite occurs near the tops of the clay beds rather than within the clay or at the base of the beds. There are coarsely pitted, and honeycombed rocks here which contain a higher percentage of combined water than in clay, and may be halloysitic or may be taken as an indication of the alteration of clay to bauxite. The following is an analysis of the Adkins bauxite:

Alumina, Al_2O_3	60.64
Silica, SiO_2	2.30
Ferric oxide, Fe_2O_3	1.33
Titanium dioxide, TiO_2	2.00
Combined water, H_2O	30.58
Moisture	2.79
Total	99.64

Toomsboro.—On the property of Mrs. Cannon, about one mile north of Toomsboro, the writer observed fragments of white, coarsely pitted, hard clay, and bowlders of bauxite. The occurrence seems to be similar to the previously described fragmental deposits.

Dr. N. T. Carswell Property.—This property is located on the south side of the Central of Georgia Railway, 3 miles west of Toomsboro. During the writer's visit to the property, a prospecting pit had just been dug, which revealed a bauxite of high-grade. The full thickness and extent of the deposit had not been determined, and the quantity of ore is problematical until further prospecting. The bauxite here, is associated with white clays, as elsewhere throughout the county, and much of the clay is semi-indurated, pitted or nodular and in its appearance suggests bauxite. Samples from this property show nodules of pure bauxite imbedded in a matrix of bauxitic clay.

The following is an analysis of the high-grade bauxite from the Carswell property:

Alumina, Al_2O_3	61.52
Silica, SiO_2	1.18
Ferric oxide, Fe_2O_3	1.70
Titanium dioxide, TiO_2	2.70
Water, H_2O	32.76
Undetermined	.14
Total	100.00

Irwinton Localities.—On the old Chambers place, 1½ miles southwest of Irwinton, owned by Andrew Underwood (colored) there are hard, rounded bowlders of flinty, amorphous bauxite with scattered concretions, in a cultivated field. The bauxite occurs in the loose soil, and is doubtfully in the place in which it formed, and hence there is but little prospect of a bauxite bed being found underneath the fragments. There are a number of outcrops, in this vicinity, of indurated, pitted and nodular white clays at a higher level than the bauxite fragments. From present conclusions concerning the occurrence and origin of the mineral, bedded deposits are most likely to be found near the top of the white clays.

The bauxite here is of exceptional purity.

Alumina, Al_2O_3	62.46
Silica, SiO_2	4.72
Ferric oxide, Fe_2O_3	.81
Titanium dioxide, TiO_2	.23
Water, H_2O (combined)	31.03
Total	99.25

On the J. R. McNeal place, 5 miles west of Irwinton, there is a hard rock deposit, whose bauxite nature would not at first be suspected. The rock has an unusual appearance from the fact that it is made up of dark red pebbles imbedded in a light colored matrix, and it has a conglomeratic appearance. It is quite hard and stony and has been used locally for many years for building foundations and chimneys. It is both highly ferruginous and siliceous; does not possess the characteristic pisolitic or concretionary structure of the bauxite of other localities, but is made up of red, smooth pebbles, some perfectly round and about the size of buckshot, and others of irregular shape and as much as 1½ inches in diameter, and a siliceous matrix in which free quartz and mica may be detected. The pebbles appear to have been water-worn, and suggest that they were originally clay, and have subsequently been altered in place. The exact geological position of this peculiar deposit can not be observed, but it is probable that it lies at the base of the Tertiary strata of this locality; also hard and semi-indurated white clays occur and it is probable that these are Cretaceous and that the bauxite is in the same geological position as at other localities in Wilkinson county. No prospecting or development work has been done and the full thickness of the bed has not been determined. Judging from the thickness of large blocks exposed at the surface, it attains at places a thickness of 3 feet. The indications are that there is an extensive deposit.

The following are analyses of the bauxitic rock from this locality:

	I	II
Alumina, Al_2O_3	41.97	42.73
Silica, SiO_2	17.50	15.57
Ferric oxide, Fe_2O_3	18.24	14.99
Titanium dioxide, TiO_2	2.65	1.84
Combined water, H_2O	16.83	20.29
Moisture	2.65	2.79
Undetermined	.16	.....
Total	100.00	98.21

The high percentages of silica and iron oxide seriously affect the value of the rock as a bauxite, and it can be of but little commercial value at present.

Gordon Localities.—About 6 miles southeast of Gordon on the Vinson property, there is a bauxite deposit quite similar to that on the McNeal place above described. The property is owned by W. A. Jones of Gordon. The rock is quite hard and stony. It occupies the top of a small knoll and probably underlies 10 acres at the point examined. The thickness of the bed could not be determined accurately, it probably does not exceed 3 feet. The hard rock is underlain by soft clay in the nature of a sedimentary kaolin, but highly stained by iron oxide.

The analysis of a sample of the red bauxite rock from this locality is:

Alumina, Al_2O_3	39.92
Silica, SiO_2	20.00
Ferric oxide, Fe_2O_3	16.84
Titanium dioxide, TiO_2	1.47
Combined water, H_2O	19.52
Moisture	1.25
Total	99.00

The analysis shows the material to be very low grade. A few fragments of high-grade pisolitic bauxite were observed and apparently at a higher level than the rock, but their source could not be located.

On the property of Mrs. Z. T. Miller, 3½ miles south of Gordon, bauxite appears in fragments and as nodules in the soil, overlying a bed of hard white clay, which reaches a thickness of 30 feet. No bedded deposit of bauxite has been found. It is probable that the hard white clay is itself slightly bauxitic. It has a nodular and concretionary appearance and resembles bauxite closely. The locality is a favorable one for further prospecting.

COOPER STATION.—Bauxite has been found on the farm of Mr. J. I. Etheridge, 2 miles southeast of Cooper Station, and near the line between Wilkinson and Baldwin counties. The bauxite probably does not occur in commercial quantity, but the occurrence is interesting in that it affords evidence of the alteration of clay in place to bauxite.

CONCLUSIONS

If the conclusions, concerning the origin and geological occurrence of the bauxite, presented in the first part of this report are correct, there may be an extensive area in which bauxite may be expected to occur. The points at which the bauxite are most likely to be found may be approximately located by locating the white clay beds, locally known as "chalk" beds, of the Cretaceous, since the bauxite has been found contiguous to the clay and near the contact between these beds and the overlying red sands and impure clays. Geological conditions in Twiggs, Washington, Glascock, McDuffie, and Richmond counties are similar to those in Wilkinson, and it would not be surprising to find bauxite in these counties.

INDEX

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