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THOMAS LEONARD WATSON, PH. D.
DIRECTOR

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The Clays of the Piedmont Province, Virginia

BY

H. RIES AND R. E. SOMERS

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LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, APRIL 1, 1917.

Governor Henry C. Stuart, Chairman, and Members of the State Geological Commission:

GENTLEMEN:—I have the honor to transmit to you herewith, and to recommend for publication as Bulletin No. XIII of the Virginia Geological Survey Series of Reports, a manuscript and illustrations of a report on "The Clays of the Piedmont Province, Virginia," by Professors Ries and Somers.

The clays of the Piedmont province are abundant, but at present they are developed to only a comparatively small extent. This bulletin, prepared to meet an urgent demand for accurate information on the clay resources of this province, should aid in the greater development and utilization of the clays.

Respectfully submitted,

THOMAS L. WATSON,
Director.

THE CLAYS OF THE PIEDMONT PROVINCE, VIRGINIA

By H. Ries and R. E. Somers.

INTRODUCTION.

The field work for this report was carried on during the season of 1915, and the laboratory tests during the following winter. In the course of the work an effort was made to visit all parts of the Piedmont region, which were located within a sufficient distance from the railroad to permit any clay deposits they contained being worked.

Samples for testing were collected not only from the different geological formations, but, where these were of considerable extent, samples were obtained from the same formation at a number of different points. These samples were of two sizes, namely, large and small.

The large samples were taken chiefly from those localities which were specially well located for establishing a plant, or where the outcrops were large. The small samples were taken in part from less important localities, and to obtain a clue regarding the nature of the clay from a given formation at points other than those supplying the large samples.

TESTING THE CLAYS.

To the practical clay worker, the physical characteristics of the clay are of prime importance, the chemical analysis being of little or no value. It was consequently the former class of properties that were investigated. All samples were carefully taken, so as to represent the average of the deposit, and not a selected sample.

The clays so obtained were put through a crusher with 1/8-inch opening, so as to break up the stony fragments, and the ground material was then mixed with water to a plastic mass. From this bricklets were molded by hand, and these were used to determine the average air shrinkage. The same bricklets were then slowly fired to cones[a] 010, 05, 03, and 1, or higher

[a]Cones or Seger Cones are a series of artificial mixtures, molded into slender pyramids. The series range from 022 to 01, then 1 up to 39. The first named has the lowest fusion point, and the last named the highest. The theoretic fusion points of successive numbers differ by 20° C. Thus 010 used in this report fuses at 950° C; 05 at 1050° C; 03 at 1090° C; and 1 at 1150° C. As the temperature approaches the fusion point of the cone the latter begins to soften and bends over until the tip touches the base, when the fusion point is supposed to have been reached. The cones are not however used for temperature measurements, but for determining pyro-chemical effects. Thus, if a certain clay develops a body of the proper quality at say Cone 1, this number cone can be placed in the kiln to be used as a gauge of the firing process.

if necessary, and the fire shrinkage, absorption, and color, after burning, determined on them.

Another lot of the mixed plastic clay was molded into briquets. These were first dried slowly in the air, and then in a hot-air bath, after which they were tested to determine their tensile strength. As some doubt exists regarding this last-mentioned test, a word of explanation should be given.

The tensile strength expresses the resistance of the air-dried clay to rupture. A clay of good tensile strength will stand handling in its unburned condition better than one of low tensile strength. Moreover, this property conveys to us an idea of the clay's bonding power. On the other hand, it is not a direct measure of the plasticity as some believe, nor does it indicate the probable strength of the clay after burning. Another fact brought out by these tests is that a clay may have a very low tensile strength, and yet flow smoothly through the die of a stiff-mud machine. The individual briquets sometimes show considerable variation in strength, and it has been suggested that this might be decreased by adding a certain amount of a standard sand. This, of course, may decrease the average tensile strength of the clay, and so for purposes of comparison all clays to be compared should be treated in the same way.

Still another lot of the large samples collected was put through a small power-driven stiff-mud machine, and the results are given in the tests. If the clay worked well in the brick die, it was also tried in the hollow block, and other dies.

While the stiff-mud tests can be regarded as giving clues to the workability of the clay by this process, their failure in some cases is not necessarily to be regarded as decisive, for the reason that almost every clay in stiff-mud work is a problem by itself; and, while it may not work well in one type of die, it often does in another.

Another lot of the clay was dry-ground to pass through a 20-mesh sieve, and molded in a hand-power dry-press machine. Most of the Piedmont clays failed here, because of their grittiness.

The kaolins were burned not only in their crude condition, but were also put through a washing test to eliminate the grit, and the washed product fired at the proper temperature.

ORIGIN OF THE PIEDMONT CLAYS.

The clays of the Piedmont region fall into three classes, namely, (1) residual, (2) colluvial, and (3) transported.

RESIDUAL CLAYS.

These are derived from all rocks by weathering processes. As a result rocks like granites, gneisses, and schists are broken down to a clayey mass—the residual clay. Since the weathering agents begin their attacks on the surface, and work from there into the rock mass, the decomposition is most complete above, and gradually diminishes downward until fresh, undecomposed rock is reached. We therefore often find that at the surface, and extending downward for a variable depth, the rock may be so completely decomposed that little of the original structure remains. This may grade downward into a second poorly-defined zone in which the material is pretty well weathered, but the rock structure is still retained. Below this there may be a third zone, partly decomposed, and containing some partly-decayed rock fragments, which in turn grades into the solid rock.

The depth of these several zones may vary, and each one is not always present. The clay of the upper zone is usually the most plastic,[a] while that of the second may be noticeably less so. This is an important feature to recognize, because the upper zone alone may not be deep enough to work, and so in taking a sample it is necessary if possible to include some of the lower-lying material.

Residual clays vary greatly in depth, and even within a short distance may show great irregularity in thickness, this variation being due to unevenness of either the land surface or the bed rock.

Variation in depth may be due to variation in depth of weathering or erosion. On a flat surface the residual clay is likely to accumulate, as it is not washed away, while on a slope or ridge crest where the rain wash removes the soil rapidly, unless protected by vegetation, the products of weathering are apt to be removed. Bearing these facts in mind, we can see the necessity of carefully determining the extent and depth of a deposit of residual clay.

Most residual clays are colored yellow, brown, or red by iron oxide, which is supplied by the decomposition of iron-bearing silicates like biotite mica,

[a] Tillage of residual clay sometimes loosens the upper few inches so that the surface water washes out the clay particles. The surface soil may therefore appear sandy or loamy, but be immediately underlain by the sticky clay of the upper zone.

hornblende, etc. If these minerals are absent the clay is white or nearly so. The ferruginous residuals burn red or brown, while the whitish ones usually burn white or light buff.

The crystalline rocks from which most of the Piedmont residual clays are derived often contain veins of quartz, which in weathering do little more than break up into angular fragments. These remain scattered through the clay, and must be crushed or screened out before the material can be put through the molding machine.

COLLUVIAL CLAYS.

In many localities, the residual clays formed on hillsides are moved a comparatively short distance down slope, the action being partly a sliding of the deposit down hill, and partly a wash process. Such deposits are termed *colluvial.*

TRANSPORTED CLAYS.

As residual clays are washed down the slopes of the land they reach the streams, and are carried along by the current, until it slackens enough to deposit them. The clay so deposited is called a transported or sedimentary clay. We may therefore get several types of transported clay, depending on the conditions of deposition.

FLOOD PLAIN CLAYS.

These represent a common type in the Piedmont region. They include the clayey sediment deposited by streams on the flat tracts (flood plains) which often border the river courses. Many of the streams flowing across the Piedmont belt are bordered by flood-plain terraces underlain by clay.

These clays are rather characteristic in their occurrence. They vary from plastic to sandy, and the clay may grade into sand both vertically and horizontally. So there is an equally great need here for testing the deposit thoroughly before locating a plant on it.

MARINE CLAYS.

Clayey sediment may be carried by streams into estuaries or to the sea before it settles to the bottom. The latter case especially may yield deposits of wide extent. If these sediments are later covered by a great thickness of additional beds, they become hardened or consolidated to form *shale.* The latter, however, when ground up and mixed with water, may become quite plastic, especially if the individual shale grains cohere by pressure alone.

Shales vary from hard gritty ones like those at Leaksville Junction west of Danville to smooth fine-grained ones like those at Wolftrap.

They may form deposits of considerable thickness, of clean material from top to bottom, or at other times beds of sandstone are interstratified with the shale. As these do not always weather as readily as the shale, their presence even in residual clays derived from shale is at times a source of trouble in excavating.

MINERAL COMPOSITION OF THE PIEDMONT CLAYS.

The mineral composition of the Piedmont clays is shown in tabular form on pages 7 and 8.

The determinative work was done with the petrographic microscope. Samples of each clay were powdered and made into microscopic mounts, the specimens usually being imbedded in Canada balsam. In some cases special determinations had to be made by putting the grains in liquids of higher index of refraction.

The minerals noted were quartz, muscovite, biotite, chlorite, epidote, zoisite, hornblende, feldspar, zircon, tourmaline, rutile, titanite, garnet, magnetite, ilmenite, sericite, hydromica, and kaolinite. The term hydromica[a] is used to designate a mineral whose optical characters vary from those of sericite and possibly biotite to kaolinite. There is probably an isomorphous gradation between sericite and kaolinite, at least, with a gradual loss of potash and the addition of water, and in weathering products such as these, hydromica represents a transition stage of weathering toward kaolinite as the final product.

In every clay examined quartz is present, varying in size down to the minimum limit of vision of the microscope. Biotite is nearly as common and usually more or less bleached from loss of iron. Muscovite, strictly speaking, is very rare, the colorless mica of high double refraction generally having that minute scaly character which classes it as sericite. Chlorite is comparatively uncommon, but a few small grains of epidote are to be found in the majority of the clays. Zoisite is present only in the Roseland kaolins and in three of the transported clays, while few are sufficiently fresh to retain the hornblende. Feldspar is commonly seen, although never in large quantity, and the varieties orthoclase, microcline, and plagioclase may be distinguished. Zircon, tourmaline, and rutile are not un-

[a] See Galpin, S. L., Studies of Flint Clays and Their Associates, Trans. Am. Ceramic Soc., Vol. XIV, pp. 306 and 338, for an excellent discussion of this term.

common, although present in very small amounts, but titanite, garnet, magnetite, and ilmenite are very rare. Sericite has been noted in a few of the clays, but as a rule seems to have gone over into either hydromica or kaolinite. These two latter minerals are never lacking, and although varying in relative abundance, compose most of the finer particles of the clays.

The residual clays are grouped in the table according to the rock formation from which they were derived, with the pegmatitic and similar clays by themselves, and a group at the end to include all the transported clays.

Comparing the different groups, it is noticeable that the transported clays contain a greater variety of minerals than the residual ones. Among the latter the greatest development of kaolinite is found in the kaolins, as might be expected, but in the other clays the mineral composition seems to depend more upon the composition of the original rock and less upon the degree of alteration. The simplicity of the Cambrian residuals and the abundance of quartz and biotite in those derived from the pre-Cambrian granite-gneiss reflect the compositions of their parent rocks.

The symbols A, C, and S are used to denote the relative quantities of the minerals. A indicates that the mineral is relatively abundant, C that it is common, and S, scarce.

A more detailed petrographic discussion of these and other clays tested, together with the practical bearing of the investigations, will be taken up in the final report.

TABLE SHOWING MINERAL COMPOSITION OF PIEDMONT CLAYS.[a]

Symbols A, C, and S denote relative quantities of minerals. A, mineral is relatively abundant; C, mineral is common; S, mineral is scarce. For symbol in third column under "Formation" see geological map, Plate I.)

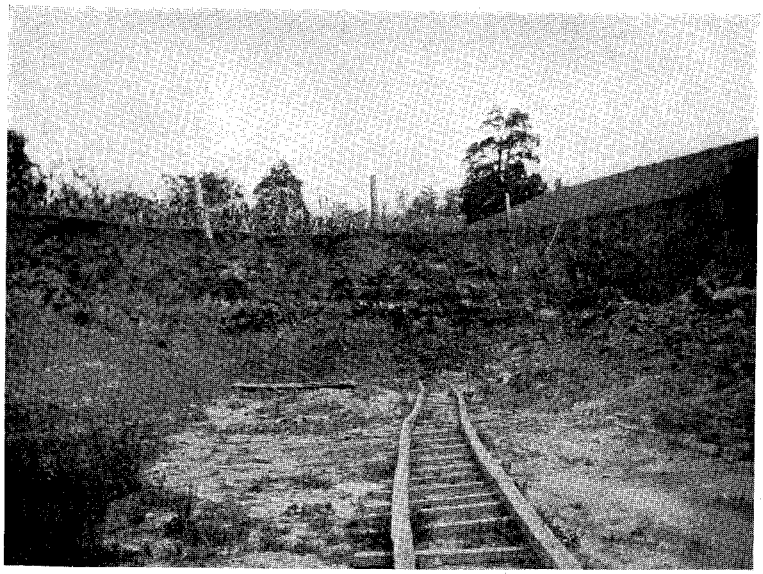
Number	LOCATION	Formation	Quartz	Muscovite	Biotite	Chlorite	Epidote	Zoisite	Hornblende	Feldspar	Zircon	Tourmaline	Rutile	Titanite	Garnet	Magnetite	Ilmenite	Sericite	Hydromica	Kaolinite
2001....	Orange	Tn	A	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	A	C
2002....	"	"	C	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...	C	A
2003....	Montpelier	"	C?	...	S	S	...	...	...	...	...	...	...	...	...	...	...	...	A	S
2008....	Elkwood	"	S	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	A	C
2009....	Brandy	"	S	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	A	C
2013....	Between Culpeper and Elkwood	"	A	...	S	S	S	...	...	...	S	...	S	...	...	...	...	...	A	C
2018....	Culpeper	"	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	C	A
2020....	Calverton	"	C	...	S	...	C	...	...	...	...	...	...	...	...	...	...	...	A	C
2021....	"	"	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	A	A
2037....	Wolftrap	"	S	...	C	...	...	...	...	...	...	...	...	...	...	...	...	...	A	A
2039....	Farmville	"	A	...	A	...	S	...	...	S	...	...	...	...	...	...	...	...	A	C
2073....	"	"	A	...	C	...	S	...	...	...	...	S	...	...	...	...	...	...	A	C
2211....	Moseleys Junction	"	A	...	C	...	S	...	...	...	S	...	...	...	...	...	...	...	C	A
2103....	Arvonia (3 mi. S. S. E.)	Orc	C	...	C	...	S	...	...	...	...	S	...	...	...	...	...	...	A	C
2104....	" "	"	S	...	S	...	...	...	...	...	...	S	...	...	...	...	...	...	A	A
2105....	" (Ferncliff)	"	C	...	C	...	S	...	...	...	...	...	...	...	...	...	...	...	C	C
2106 (+2107)	" (Le Sueur)	"	S	...	A	A	S	...	...	...	...	S	...	...	...	S	...	...	C	S
2108 (+2109)	Between New Canton and Arvonia	"	C	...	A	C	...	...	...	...	...	C	...	...	...	...	...	...	C	C
2004....	Orange	Ca	S	...	A	...	S	...	...	...	...	...	...	...	...	...	...	...	A	S
2005....	Between Orange and Madison Run	"	S	...	A	...	A	...	...	...	...	...	...	...	...	...	...	...	A	C
2016....	Culpeper	"	S	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...	A	S
2017....	"	"	A	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	C	S
2026.. 2027..	City Farm Station	"	C	...	S	...	...	...	...	...	S	...	...	...	...	...	...	...	C	C
2056....	Altavista	"	C	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	S	S
2075....	Near City Farm	"	S	...	S	...	...	...	...	...	...	S	...	...	...	...	...	...	A	S
2080....	Gordonsville	"	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	A	A
2084....	"	"	C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	A?	A?
2095....	"	"	C	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	A	S
2085....	Keswick	"	S	...	...	...	...	...	...	...	...	...	S	...	...	...	...	...	A	A
2215....	Charlottesville	"	C	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	C	C
2015....	Culpeper	Ac	A	...	A	...	S	...	...	...	S	...	...	...	...	...	...	...	C	C
2019....	Warrenton (2 mi. N. E.)	"	A	...	C	...	...	...	...	...	...	...	...	...	...	...	...	...	A	C
2025....	" (S.)	"	C	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	C	C
2035....	Gordonsville	"	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	S	A
2048....	Virso (⅓ mi. W.)	PCq	C	...	...	...	C	...	...	...	...	...	...	...	...	...	...	...	A	S
2058....	Virgilina	PCv	S	...	A	...	...	...	...	S	...	...	...	...	...	...	...	...	S	S
2062....	Simplicity	"	C	...	S	...	...	...	...	...	...	S	...	...	...	...	...	...	A	S
2011....	Blackstone	PCgr	A	...	A	S	S	...	...	...	...	...	...	...	...	...	...	...	C	C
2208....	"	"	A	...	A	...	S	...	...	...	...	...	...	...	...	...	...	...	A	S
2010....	Kenbridge	"	A	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	C	C
2028....	Alberta	"	A	...	A	...	...	...	...	...	S	...	...	...	...	...	...	...	C	C
2032....	Fredricksburg (S.)	"	A	...	A	...	...	...	A	S	...	...	...	...	...	...	...	...	S	S
2033....	"	"	A	...	A	...	C	...	A	...	...	...	...	...	...	...	...	...	S	S
2041....	Virso	"	C	...	S	...	S	...	...	...	...	...	...	...	...	...	...	...	A	C
2046....	"	"	A	...	...	...	...	...	...	...	...	...	S	...	...	...	...	...	A	C
2042....	Meherrin	"	A	...	A	...	C	...	...	...	S	...	...	...	...	...	...	...	A	S
2089....	"	"	C	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	A	C
2049....	Burkeville	"	A	...	A	...	S	...	...	S	S	...	...	...	...	...	...	...	C	A
2207....	"	"	A	...	S	...	...	...	...	C	S	...	...	...	...	...	...	...	S	S
2051....	Cumberland	"	C	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	A	S
2044....	"	"	A	...	C	...	...	...	...	S	S	...	...	...	...	...	...	...	A	A
2055....	Crozet	"	A	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	C	A?
2076....	"	"	S	...	S	...	...	...	...	...	S	...	...	...	...	...	...	...	A	C
2078....	"	"	C	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	A	S
2057....	Amherst	"	C	...	A	...	...	...	...	S	...	...	...	S	...	...	...	...	C	S
2074....	"	"	S	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	A	S
2093....	"	"	A	...	S	...	...	...	...	S	...	...	...	...	...	...	...	...	C	C

[a]These determinations were made by R. E. Somers.

TABLE SHOWING MINERAL COMPOSITION OF PIEDMONT CLAYS.

(Symbols A, C, and S denote relative quantities of minerals. A, mineral is relatively abundant; C mineral is common; S, mineral is scarce. For symbol in third column under "Formation" see geological map, Plate I.)

Number	LOCATION	Formation	Quartz	Muscovite	Biotite	Chlorite	Epidote	Zoisite	Hornblende	Feldspar	Zircon	Tourmaline	Rutile	Titanite	Garnet	Magnetite	Ilmenite	Sericite	Hydromica	Kaolinite
2060....	Lawrenceville	"	S	...	A	...	...	...	...	...	...	S	...	...	...	...	...	...	C	C
2061....	Dinwiddie	"	A	...	C	...	...	...	...	S	...	...	...	...	...	...	...	...	C	C
2031....	Clarksville	"	A	...	S	...	...	...	...	...	S	...	...	...	...	...	...	...	A	A
2065....	"	"	A	...	C	...	C	...	...	S	...	...	...	...	...	...	...	...	S	S
2066....	"	"	A	...	C	...	S	...	...	S	...	...	...	...	...	...	...	...	C	C
2071....	"	"	A	...	C	S?	S	...	...	C	...	...	...	...	...	...	...	...	C	S
2070....	Lacrosse	"	C	...	C	...	...	...	...	...	...	...	...	...	...	...	...	...	A	S
2082....	Louisa	"	C	...	C	...	S	...	...	S	...	...	...	...	...	...	...	...	A	S
2088....	Boydton	"	A	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	A	S
2094....	Bedford City	"	A	...	A	...	...	...	...	...	S	...	...	...	...	...	...	...	S	S
2098....	"	"	S	...	A	...	S	...	...	...	...	...	...	...	...	...	...	...	C	S
2096....	"	"	A	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	S	S
2099....	Lynchburg	"	C	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	A?	A
2140....	Michaux	"	A	...	A	...	S	...	...	...	S	...	...	...	...	...	...	S	C	C
2200....	"	"	A	...	A	...	S	...	...	...	...	...	...	...	...	...	...	...	C	C
2204....	Nottoway	"	C	...	A	...	S	...	...	...	...	...	...	...	...	...	...	...	C	C
2209....	Ballsville	"	C	...	A	...	...	...	...	S	...	...	...	...	...	...	...	...	S	S
2210....	Powhatan	"	C	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	C	C
2212....	Moseleys Junction (½ mi. E.)	"	C	...	C	...	S	...	...	...	...	...	...	...	...	...	...	...	A	C
2214....	Claysville	"	A	...	C	...	S	...	...	S	S	...	...	...	...	S	...	...	A	S
2022....	Cabin Branch	PCc	A	...	...	A	A	...	...	...	...	...	...	...	...	...	...	C	S	S
2029....	Danville	"	C	...	C	...	...	...	...	...	...	...	...	...	...	...	...	...	A	C
2063....	Danville W.	"	A	...	S	...	C	...	...	...	...	...	...	...	...	...	...	...	A	S
2072....	Chatham	"	C	...	A	...	S	...	...	S	S	...	...	...	...	...	...	...	A	S
2079....	Appomattox	"	C	...	C	...	S	...	...	...	...	...	...	...	...	...	...	...	A	C
2064....	Between Appomattox and Pamplin	"	A	...	A	...	S	...	...	...	...	S	...	...	...	...	...	...	C	C
2086....	Pamplin	"	S	...	C	...	...	...	...	...	...	...	...	...	...	...	...	...	C	C
2087....	Louisa	"	S	...	A	...	S	...	...	S	S	...	...	...	...	...	...	...	C	C
2081....	Mineral	"	S	...	A	...	S	...	...	S	S	...	...	...	...	...	...	...	A	C
2100....	"	"	A	...	S	...	S	...	...	...	...	...	...	...	...	...	...	...	A	C
2198....	Motley	"	C	...	A	...	S	...	...	S	...	S	...	...	...	...	...	...	S	S
2030....	Pamplin	Pegmatite	C	...	...	...	S	...	...	...	...	...	...	...	...	...	...	?	A	C
2186....	Motley	"	C	C	S	...	...	...	...	S	...	...	...	...	...	...	...	C	C?	A
2169....	Roseland	Crude kaolin	C	...	...	...	...	C	...	S	...	...	...	...	...	...	...	...	C	A
2168....	"	Kaolin	C	...	S	...	...	C	...	S	...	...	...	...	...	...	...	...	C	A
2167....	"	Washed kaolin	S	...	...	...	...	S	...	S	...	...	...	...	...	...	...	...	C	A
2166....	"	Tailings	A	...	S	...	...	A	...	A	...	...	...	...	...	...	...	...	C	S
2171....	Near American Rutile Co.'s Mill	Residual	A	...	A	...	...	...	...	...	...	...	...	...	...	...	...	...	C	S
2006....	Culpeper	Flood plain	A	...	S	S	S	S	...	...	S	...	...	...	S	...	...	...	A	S
2007....	"	"	A	...	S	C	S	...	...	S	S	...	...	...	...	...	...	...	C	A
2014....	"	Transp.	C	S	S	...	S	...	...	...	S	...	...	...	...	...	...	...	A	C
2023....	Stevensburg	"	C	...	...	S	S	...	...	...	...	...	...	...	...	...	...	...	A	C
2043....	Reusens	Col.?	A	...	C	...	C	...	A	...	S	...	S	...	...	...	...	...	A	C
2047....	"	"	A	...	S	...	...	...	C	...	...	...	...	...	...	...	...	...	A	A
2052....	Meherrin	Flood plain	C	...	C	S	C	S	...	...	S	...	S	...	...	...	...	...	A	C
2067....	Chatham	Col.	A	...	C	...	S	...	...	...	S	...	S	...	...	...	...	...	A	A
2068....	Lawrenceville	Flood plain	C	...	...	...	S	...	...	...	S	...	...	...	...	...	...	...	A	A
2206....	"	"	A	...	...	...	S	...	...	S	...	...	...	...	...	...	...	...	A	C
2069....	Brodnax	"	S	...	S	...	S	...	...	...	S	...	...	...	...	...	...	...	A	C
2139....	Michaux	Transp.	C	...	S	...	S	...	...	...	S	S	...	...	...	...	...	...	A	C
2077....	"	Strained from No. 2139	S	...	S	...	...	...	...	...	S	...	S	...	...	...	...	...	A	C
2040....	Danville	Flood plain	A	...	C	...	S	...	...	S	S	S	...	...	...	...	...	...	C	S
2091....	"	"	C	...	C	...	C	C	S	S	...	...	...	...	...	...	...	...	A	S
2101....	Arvonia	Col.	C	...	S	...	...	...	...	...	S	S	...	...	...	...	...	...	A	A
2170....	Colleen (1,000 yds. S.)	Wash	A	...	C	...	S	...	...	C	S	...	S	...	...	...	S?	...	S	S



(A) Bank of transported clay, Ward Bros.' yard, Galax.

(B) Pit in flood plain clay, Culpeper.

(A) Bank of transported clay, Ward Bros.' yard, Galax.

(B) Pit in flood plain clay, Culpeper.

DETAILED DESCRIPTIONS AND TESTS OF THE PIEDMONT CLAYS.

FLOOD PLAIN CLAYS.

Most of the larger streams in the Piedmont belt, and even many of the smaller ones, are bordered, sometimes for long stretches, by flood-plain terraces. These terraces are of varying width, and may be almost at the stream level or 15 to 20 feet above it.

The surface soil of the terrace is often sandy, while underlying it may be clay or sand, the pockets, lenses, or layers of the two often irregularly distributed. The flood-plain clays are often more plastic and denser-burning than many of the residual clays, and where obtainable seem to be preferred by the brick manufacturer.

Good examples of this type of deposit are worked at Drakes Branch, Danville, Deacon near Lynchburg, and Culpeper.

CULPEPER COUNTY.

Culpeper.—Stream or flood-plain clays are worked at Clarke's brickyard on the northeastern edge of town. The plant is not a very large one, and hence the quantity of clay required is comparatively small. It is supplied from what is probably a flood-plain deposit bordering Mountain Run, but only that portion lying on the south side of the creek is worked. This shows the variable nature so characteristic of many flood-plain deposits. Thus nearest to the works the surface is underlain by a tough blue clay (Lab. No. 2007), about 5 feet thick, while on the farther side of the pit, towards the highway, there is a yellow, less sticky clay (Lab. No. 2006), and again, next to the run the clay becomes very sandy.

The blue clay has too much shrinkage and is too tough to work alone, consequently it is mixed with the yellow, which is of lower shrinkage. The difference in the physical character of the two clays is well shown by the following few tests that were made on them.

Lab. No. 2007, blue clay.—Although this clay is gritty, it is also very plastic. It worked up with 34 per cent water to a mass whose air shrinkage was 8.4 per cent. The bricklets were hard with a good ring even at Cone 010. At Cone 010 the fire shrinkage and absorption were 2 and 13 per cent, respectively, while at Cone 05 they were 4.6 and 12 per cent.

Lab. No. 2006, yellow clay.—This clay, although gritty, has good plasticity. With 24 per cent water it gives a workable paste that shows

5.9 per cent air shrinkage on drying. The clay burns red, and gives a hard body at Cone 05, although at Cone 010 the product is fair. In firing the bricklets, those heated to Cone 010 had a fire shrinkage of 0 per cent, and an absorption of 19.3 per cent, while those fired at Cone 05 showed 1 per cent fire shrinkage, and 15 per cent absorption.

It is seen then that by mixing the two together we overcome the higher shrinkage of the one, and the more porous-burning character of the other.

The output of the yard consists at present of common brick. The clay is prepared by passing through rolls, from which it goes to an end-cut, stiff-mud machine. The bricks are dried under sheds, and burned in scove kilns with permanent side-walls. The product has a good ring.

CAMPBELL COUNTY.

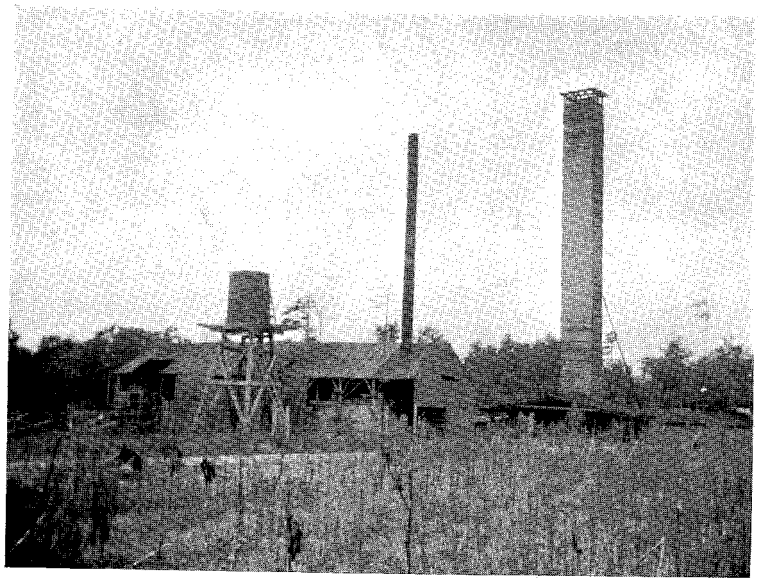
Deacon.—The flood plain bordering James River is underlain by a typical river deposit that varies from sand to plastic sandy clay, there being at times enough of the latter to warrant working it for the manufacture of brick. Such a deposit has been opened up at Deacon, on the Chesapeake and Ohio Railroad, about 6 miles east of Lynchburg, and is utilized by the firm of Adams Bros.-Paynes Co., for making common building brick.

The clay underlying the flood-plain surface averages about 10 feet in depth, but at times is as much as 14 feet. It is excavated by means of a steam shovel, prepared with rolls and pugmill, and molded in a soft-mud machine. Tunnel dryers and permanent side-wall, updraft kilns complete the outfit. The product supplies much of the Lynchburg market.

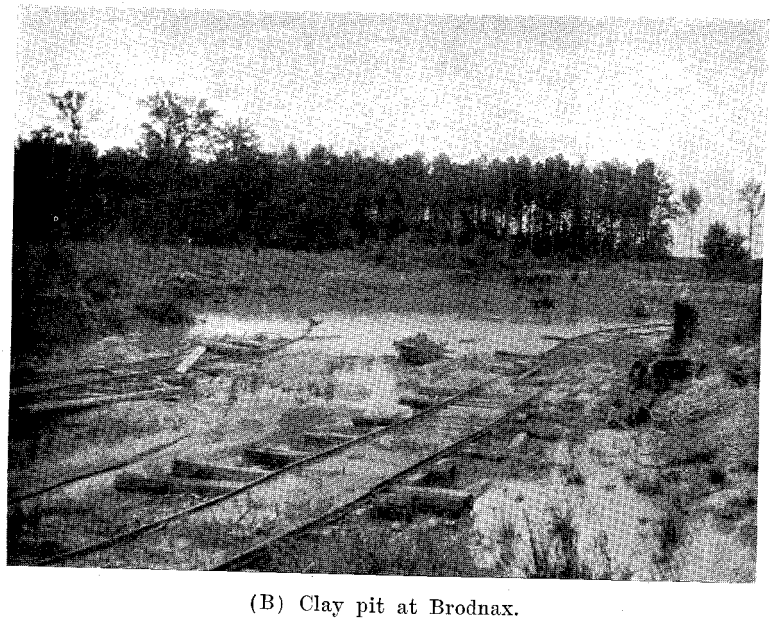
AMHERST COUNTY.

Reusens.—On the north side of James River, about 500 yards east of the blast furnace of the Oriskany Ore and Iron Corporation, and on the property of T. L. Wills, there is a curious deposit of clay about 50 feet above the river level. It lies higher than the surface of the flood-plain terrace, and is not a recent river deposit; at the same time the presence of a number of rounded pebbles and cobbles in the clay indicate that it is probably some type of transported material, and not a purely residual deposit.

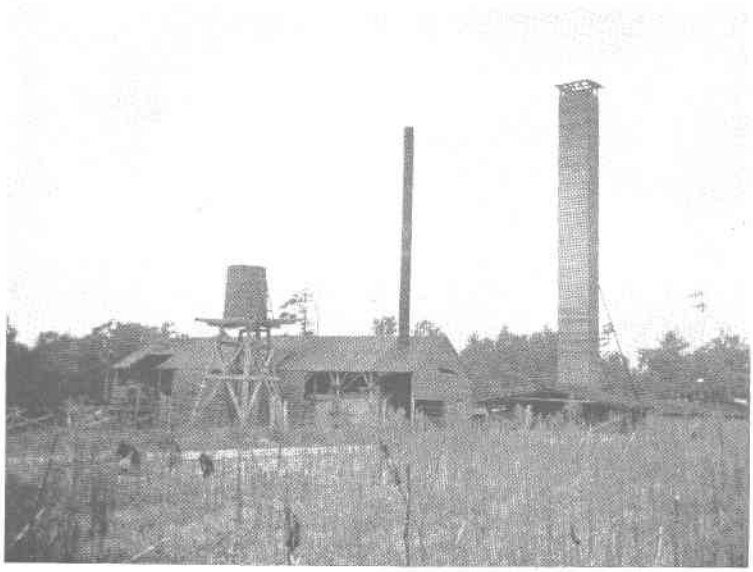
The upper five feet of the deposit is a ferruginous sandy clay (Lab. No. 2047), with scattered, rounded pebbles. Under this is a gray, gritty clay, 4 to 6 feet in thickness (Lab. No. 2043), containing pebbles and cobbles of quartz, coarse feldspar, and biotite schist. The material is interesting, because it serves well for use as a fire-mortar clay and for tamping at the blast furnace.



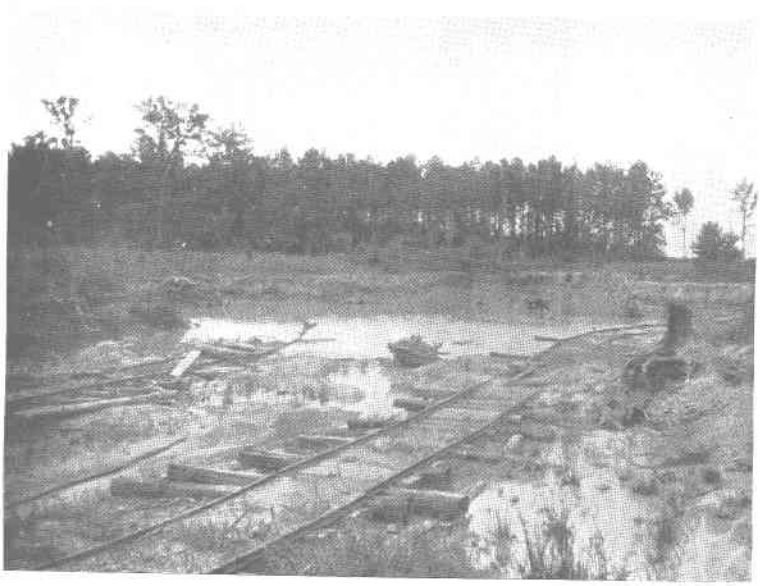
(A) Brick works at Brodnax.



(B) Clay pit at Brodnax.



(A) Brick works at Brodnax.



(B) Clay pit at Brodnax.

There is not much difference between the two clays as the following few tests indicate.

Lab. No. 2047.—A brown, sandy, plastic clay of red-burning character, with 5.8 per cent air shrinkage and low fire shrinkage. It has about 15 per cent absorption at cones 010 and 05.

Lab. No. 2043.—This has 6.1 per cent air shrinkage, very low fire shrinkage, and 13 per cent absorption.

LUNENBURG COUNTY.

Meherrin.—Stream clay is known to occur about 1 mile southwest of Meherrin, on the Richmond and Danville division of the Southern Railway. It is referred to as white, but is of a light gray color, and this fact has led some to think it a fire clay. Indeed it was this rumor which attracted our attention to it. The material (Lab. No. 2052) is a smooth, plastic clay, which shows 5.6 per cent air shrinkage, after being mixed up with 25 per cent water. The clay burns red, and has an excellent ring at Cone 010. At Cone 010 the fire shrinkage and absorption were 1 and 14.2 per cent, respectively. At Cone 05 these two values were 1.4 per cent and 13.1 per cent.

From these few trial tests, the material gives promise of being adapted to the manufacture of a good red brick, but it is not a fire clay.

Virso.—More stream clay occurs at this point about 1¾ miles southwest of Meherrin. The material is of light gray color and undoubtedly very similar to the preceding.

BRUNSWICK COUNTY.

Brodnax.—One mile northwest of Brodnax, and about 100 yards south of the Lacrosse-Brodnax road, is an old clay pit of the Chase Brick and Tile Corporation. The deposit lies in a bottom and is a transported clay. It is gray in color, with numerous iron stains, and fairly plastic in its nature.

The clay was hauled to the works with an engine, fed into a screw mixer, then into a pugmill, and end-cut machine. It was dried in steam-heated tunnels, and burned in permanent side-wall, updraft kilns. The yard is not in operation, but the bricks at the plant lacked ring and seemed to be badly laminated.

A sample of the material (Lab. No. 2069) collected by us, worked up with 34 per cent water, had an air shrinkage of 7.2 per cent. The bricklets

burned red with a good ring at Cone 010. At this Cone the fire shrinkage was 1.3 per cent, and absorption 23.2 per cent, while at Cone 05 the fire shrinkage and absorption were 4 and 20.2 per cent, respectively.

This clay makes a good common brick material, although it does not show as low absorption as some of the stream clays of the Piedmont area. It would seem from these tests that the bricks at the yard were not burned hard enough, and that the laminations were due to the machine not being suited to this particular clay.

Lawrenceville.—Transported clays are available at several points around Lawrenceville. Thus, near Great Creek about one-half mile west of town, and just south of the Southern Railway tracks, is a yard owned by W. A. Crinkley, which utilizes a flood-plain clay. The clay is light gray and very plastic, with streaks of limonite. It closely resembles the Brodnax material described above. At the yard the clay is put through rolls, pugmill, and end-cut, stiff-mud machine, dried on pallets, and burned in updraft kilns.

A small sample (Lab. No. 2206) was tested in the laboratory, with the result that it gave with 22 per cent of water a workable mass whose air shrinkage was 4.7 per cent. The material burns red, to a bricklet of moderate absorption, having a good ring at Cone 010, and being nearly steel hard. At Cone 010 the fire shrinkage was zero, and absorption 15.5 per cent. At Cone 05 the fire shrinkage was 1 per cent, and absorption 15.2 per cent. This clay should make a good common brick.

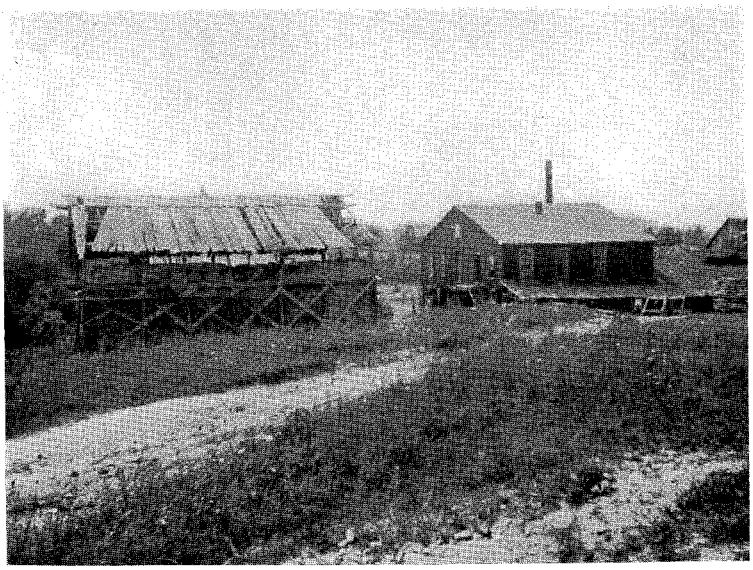
Another flood-plain deposit, located in the flood plain of Rose Creek, is worked northeast of town by the students of St. Paul's College (colored).

The clay is treated with rolls, pugmill, stiff-mud machine, and burned in updraft kilns. The brick are fair, and should be burned harder, for the following tests on a sample from here (Lab. No. 2068) show that the clay burns to a good body at a low heat. It gave with 21 per cent water a workable body of fair plasticity, having 6.3 per cent air shrinkage. The bricklets molded from this burned to a red product, having an excellent ring at Cone 010. The fire shrinkage and absorption at Cone 010 were 1 per cent and 16.8 per cent, respectively, while at Cone 05 the corresponding values were 2.6 per cent and 13.4 per cent.

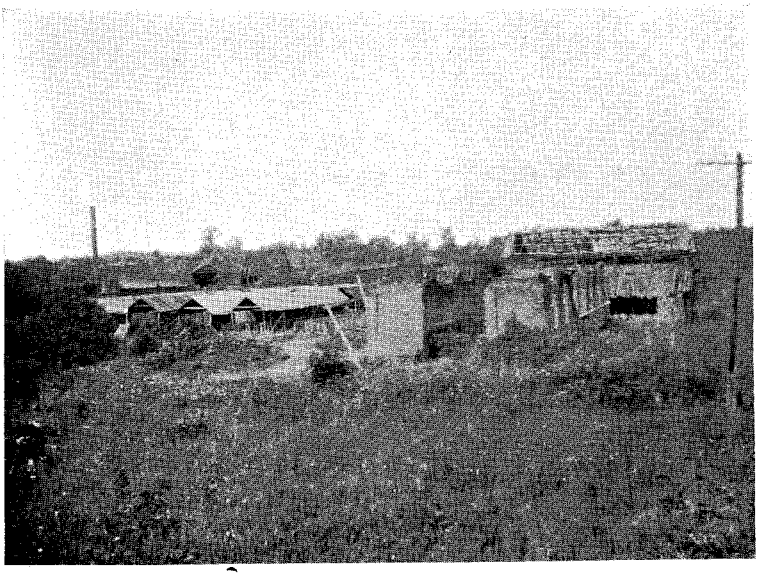
These preliminary tests point to a good brick clay.

CHARLOTTE COUNTY.

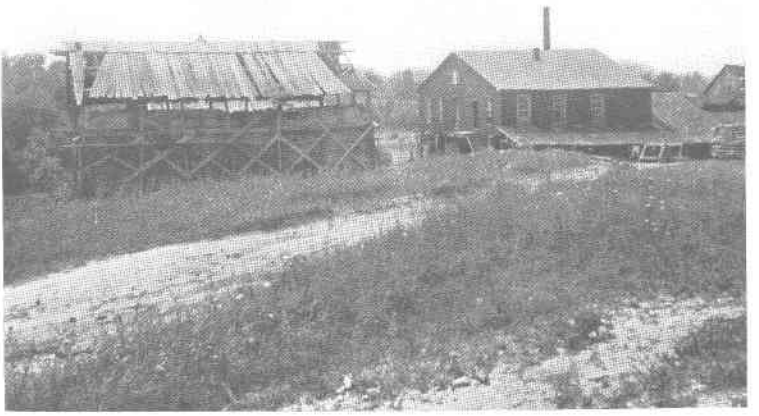
Drakes Branch.—The only clay worked at Drakes Branch, a station on the Richmond and Danville division of the Southern Railway, is a stream



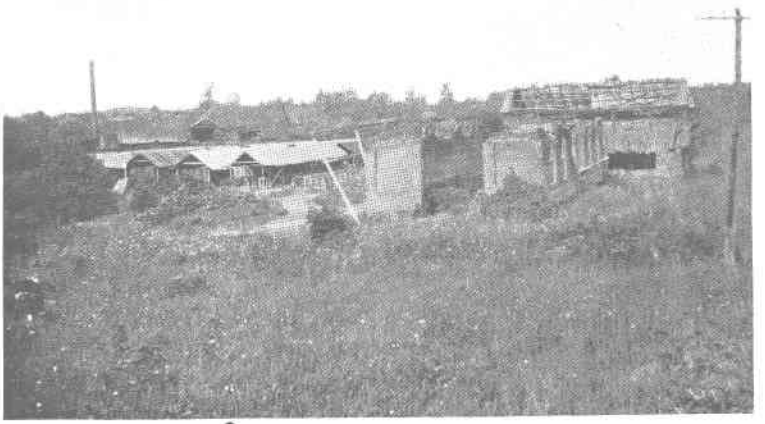
(A) Brickyard of St. Paul's school, Lawrenceville.



(B) Brickyard, Lawrenceville.



(A) Brickyard of St. Paul's school, Lawrenceville.



(B) Brickyard, Lawrenceville.

deposit which is utilized at Payne and Spindler's yard for making common brick. The yard is located on the southeast side of the railroad, and is equipped with a pugmill, stiff-mud, end-cut brick machine, dryer sheds, and scove kilns. The clay deposit is from 4 to 5 feet in depth, and underlain by sand.

Laboratory tests on this material (Lab. No. 2038) gave the following results: A brown clay of high plasticity, but working up with 23 per cent of water to an easily moldable mass. The air shrinkage was 6.1 per cent, and the average tensile strength 245 pounds per square inch. The clay burns red, with a good color up to Cone 05, but darkens at Cone 03. The bricklets had a good ring even at 010, and burned steel hard at this Cone.

Additional tests are tabulated below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.0	15.3
05	.6	14.7
03	2.0	10.3
1	2.0	10.1

This material is a good common-brick clay, which can be worked in a stiff-mud machine. It needs thorough tempering.

PITTSYLVANIA COUNTY.

Danville.—Both residual and stream clays occur in the vicinity of Danville. The latter are found bordering Dan River, and there is a possibility of finding them at a number of points. They are worked, however, only at one point, 2 miles east of Danville, along the Richmond and Danville division of the Southern Railway.

At this point Dothard and Riddle are using a flood-plain clay, running about 8 feet deep, for making common brick. The clay, which is underlain by sand, varies in its nature, there being exposed in the pit two distinct types. One of these is a loamy yellow clay (Lab. No. 2040), which is said to tear if worked alone in the stiff-mud machine. The other is a tough blue clay (Lab. No. 2091), which is said to be too plastic to work alone. The plant is equipped with a pugmill, rolls, end-cut, stiff-mud machine, Steele dryer, and updraft, side-wall kilns.

The following tests were made on three samples, representing the yellow sandy clay (2040), the blue clay (2091), and a mixture of 50 per cent of

each (2216). For purposes of comparison the tests are given in parallel columns.

	2040	2091	2216
Texture	Sandy	Fine	....
Plasticity	Fair	High	Good
Water required	27.4%	27.3%	28%
Air shrinkage	5.8%	6.0%	7.2%
Tensile strength, lbs. per sq. in.	60.0	159.0	102.0
Color burned	Red	Red	Red
Cone 010			
Fire shrinkage	0.0	.6	1.0
Absorption	20.6	19.1	19.8
Cone 05			
Fire shrinkage	0.0	2.0	1.0
Absorption	18.9	16.0	17.8
Cone 03			
Fire shrinkage	1.4	3.0	3.6
Absorption	15.9	11.8	15.7
Cone 1			
Fire shrinkage	2.6	3.0	3.7
Absorption	15.4	12.8	13.9

No. 2040 develops only fair ring at Cone 010, but is steel hard at 03.

No. 2091 gives better body at 010 than No. 2040.

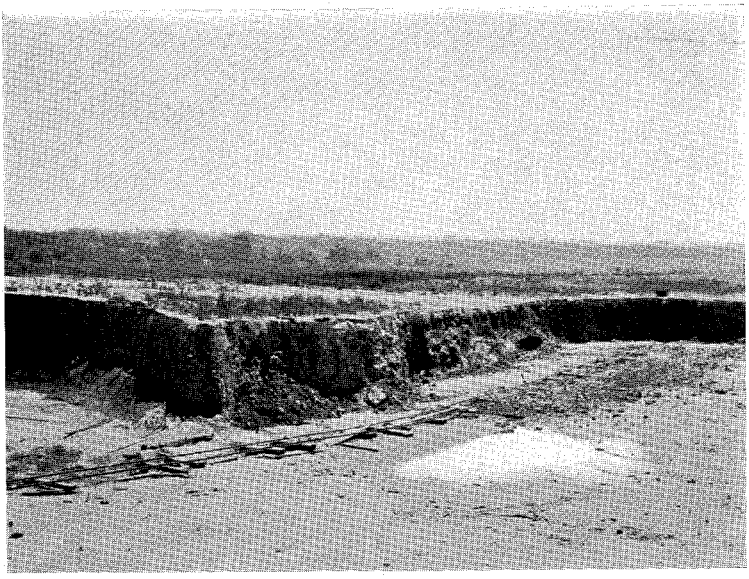
No. 2216 develops good ring at 010.

No. 2091 was run through the die of the stiff-mud machine without difficulty, but it is a tough clay, requiring considerable grinding to break up the lumps. If these are not disintegrated thoroughly the bricks show a tendency to crack. In using a mixture, thorough pugging of the clay is also necessary in order to prevent cracking.

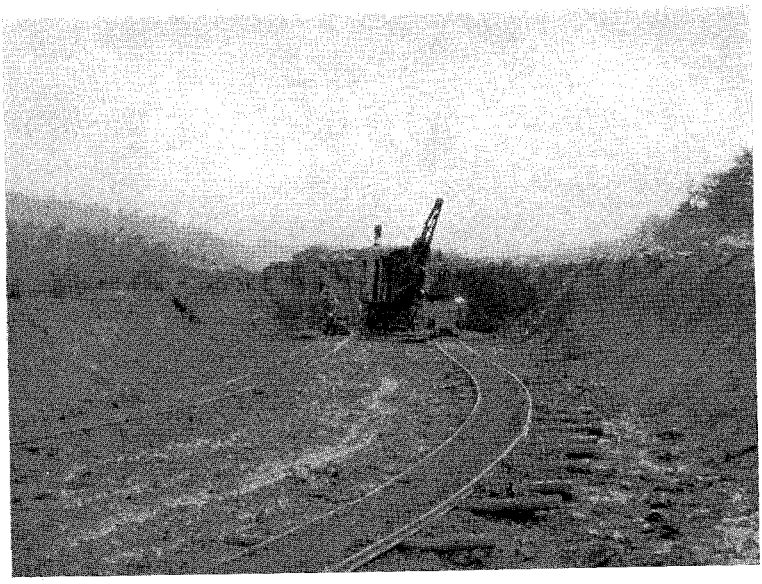
While the clay is used for common brick, it is probable that it could also be used for making drain tile and hollow blocks.

GRAYSON COUNTY.

Galax.—About half a mile southeast of Galax stream clays are being used at Ward Brothers' yard for making common brick. The deposit appears to be a delta, and the cut which has been made for digging the clay is above the level of the flood plain of the near-by stream. In this pit the clay is stratified and the upper 10 feet of the 12-foot face is a brown, smooth, plastic, micaceous clay (Lab. No. 2122).



(A) Flood plain clay, Douthat and Riddle yard, two miles east of Danville.



(B) Clay pit in flood plain deposit, Deacon, east of Lynchburg.

(A) Flood plain clay, Douthat and Riddle yard, two miles east of Danville.

(B) Clay pit in flood plain deposit, Deacon, east of Lynchburg.

This clay when worked up had 7 per cent air shrinkage. It burned to a red color, and at Cone 010 had a fairly good body. The fire shrinkage and absorption are low. They are:

Cone 010: 1.3 per cent fire shrinkage, 19.9 per cent absorption.
Cone 05: 1.3 per cent fire shrinkage, 18.9 per cent absorption.

This clay should yield a good brick.

Underlying the upper clay, and sharply separated from it, is a bluish-gray clay (Lab. No. 2114) of very plastic character, quite micaceous, and having a somewhat different fire shrinkage, as the tests below show. This, a smooth, plastic material, had 7.1 per cent air shrinkage. It burns to a red color, and forms a body with an excellent ring at Cone 010. At Cone 010 there was .7 per cent fire shrinkage, and 20.8 per cent absorption. At Cone 05, 3 per cent fire shrinkage, and 16.2 per cent absorption.

The two clays are mixed in about equal parts, and the bottom clay improves the quality of the brick; but, if it is not thoroughly pugged, the product shows a tendency to crack.

The bricks are molded in a stiff-mud machine, air dried, and burned in scove kilns. There is a possibility also of making drain tile from these clays.

Two miles east of Galax is W. C. Cole's yard. The clay which lies in a hollow also appears to be of transported character. It is plastic and micaceous (Lab. No. 2117). The pit, which is not over 5 feet deep, shows clays of brown, blue, and light-gray color, but the highly micaceous character, as shown by the following tests, seems to interfere with its making a good hard brick at the temperature of the ordinary scove kiln.

These tests show it to be of low plasticity, and 5 per cent air shrinkage. It burns to a light-red color, and does not give a very hard product. The fire shrinkage up to Cone 05 was 0 per cent, and the absorption 25 per cent.

SUMMARY OF TESTS OF TRANSPORTED CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2007	Culpeper	34.0	Good	8.4	.....	2.0	13.0	4.6	12.0	.....	.....	.....	.....
2006	Culpeper	24.0	Good	5.9	.....	0.0	19.3	1.0	15.0	.....	.....	.....	.....
2047	Reusens	21.0	Good	5.8	.....	0.0	15.4	0.0	14.7	.....	.....	.....	.....
2043	Reusens	30.0	Good	6.1	.....	0.0	13.0	1.7	13.6	.....	.....	.....	.....
2052	Meherrin	25.0	Good	5.6	.....	1.0	14.2	1.4	13.1	.....	.....	.....	.....
2069	Brodnax	34.0	Fair	7.2	.....	1.3	23.2	4.0	20.2	.....	.....	.....	.....
2206	Lawrenceville	22.0	High	4.7	.....	0.0	15.5	1.0	15.2	.....	.....	.....	.....
2068	Lawrenceville	21.0	Fair	6.3	.....	1.0	16.8	2.6	13.4	.....	.....	.....	.....
2038	Drakes Branch	23.0	High	6.1	245	0.0	15.3	.6	14.7	2.0	10.3	2.0	10.1
2040	Danville, brown	27.0	Fair	5.8	60	0.0	20.6	0.0	18.9	1.4	15.9	2.6	15.4
2091	Danville, blue	27.0	High	6.0	159	.6	19.1	2.0	16.0	3.0	11.8	3.0	12.8
2216	Danville, mixture	28.0	Good	7.2	102	1.0	19.8	1.0	17.8	3.6	15.7	3.7	13.9
2122	Galax	30.0	Good	7.0	.....	1.3	19.9	1.3	18.9	.....	.....	.....	.....
2114	Galax	40.0	Good	7.1	.....	.7	20.8	3.0	16.2	.....	.....	.....	.....
2117	Galax	33.0	Low	5.0	.....	0.0	26.6	0.0	25.2	.....	.....	.....	.....

Comments on the Table.

The foregoing tests indicate that most of the transported clays examined did not require an excessive amount of water for mixing, but were of good plasticity. The air shrinkage was usually moderate. The tensile strength is variable. Fire shrinkage is high above Cone 010, but most of them show only a moderate absorption. They are therefore good brick clays, and some are adapted to tile making. Those best adapted to tile or even to hollow brick manufacture are the ones tested from Danville, Drakes Branch, and Meherrin.

TRIASSIC CLAYS.

The Triassic formations occupy a number of disconnected areas within the Piedmont province of Virginia.

The first and largest enters the State as a belt about 20 miles wide, with Leesburg, Loudoun County, near its western border, and Manassas, Prince William County, a little farther south, near its eastern margin. This belt, forming the Virginia portion of the New York-Virginia Triassic belt, and comprising parts of Loudoun, Fauquier, Prince William, Culpeper, and Orange counties, narrows rapidly southward, and extends, with the exception of one break north of Orange, as far as Gordonsville. The clays are all residual, red burning, and derived chiefly from shales and shaly sandstones, but in some localities, as south of Culpeper, they are derived from conglomerates. The tests show that this area contains clays of economic value.

A second area, and one containing coal, lies west of Richmond, but few shales of any value have been found in it. The Richmond area includes parts of Amelia, Chesterfield, Henrico, Powhatan, and Goochland counties.

A third one of small size, known as the Scottsville area, lies west of Warren, and comprises parts of Albemarle, Buckingham, and Nelson counties.

A fourth and long belt, known as the Dan River belt, extends northeastward from the State line through Pittsylvania County into Campbell and Appomattox counties. Most of this area lies remote from the railroad. It is, however, accessible near Chatham and west of Danville, and is crossed by the main line of the Southern Railway between these two points, and again by the Danville and Western Railroad between Danville and Martinsville. West of Danville the shale is too gritty.

There are finally some small areas located, respectively, near Wolftrap, Halifax County, and between Farmville and Cumberland, which contain some good clays.

FAUQUIER COUNTY.

Calverton.—Although the region around Calverton is underlain by a broad area of Triassic rocks, which have weathered to residual clay, there are, owing to the topography, few good exposures of the material. The bedrock seems to be mostly a red, shaly sandstone. Some search was made around this locality for natural exposures of clay, but few good ones were found, and the area should be tested out by boring.

The two following samples may serve to convey some idea of the Triassic residual clay occurring in this region, although it should be remembered that the material may vary from point to point, a fact emphasized by the samples collected between Culpeper and Elkwood to the southwest.

One sample (Lab. No. 2020) collected from a pasture near Calverton was light brown, smooth, and quite sticky, requiring 30 per cent of water for tempering, and having 8 per cent air shrinkage. The air-dried sample showed a few fine cracks. The bricklets burned at Cone 010 had a good ring and good red color, with a fire shrinkage of .3 per cent, and absorption of 17.3 per cent. At Cone 05 the bricklets were steel hard, with a fire shrinkage of 4.3 per cent, and absorption of 10.3 per cent. The material can be classed as a common brick clay, and at Cone 010 should make a salable product.

A second sample (Lab. No. 2021) was taken from the railroad cut on the branch line to Warrenton. The same material shows in the neighboring wagon-road cuts, but here the bedrock does not appear to lie very deep. This is also a good brick clay, and better than the preceding. Its plasticity is fair, and there is little grit. It required 20 per cent of water for working, and the mixture had an air shrinkage of 4.9 per cent, which is not high. At Cone 010 the bricklets had a good ring and red color with a fire shrinkage of 1 per cent, and absorption of 18.9 per cent. At Cone 05 they were steel hard with a fire shrinkage of 6.3 per cent, and absorption of 8.4 per cent.

CULPEPER COUNTY.

Culpeper-Elkwood.—The wagon road from Culpeper to Elkwood traverses the Triassic formation, but there are few heavy cuts either along the railroad or the wagon road. A short distance northeast of where the main highway crosses the railroad, the residual clay from the shale is well exposed in a long, shallow cut. The location here is a good one for working as it is close to the railroad. Above the clay is 1 to 2 feet of sandy loam, which could be mixed in with the clay (Lab. No. 2013). Owing to the favorable location of the deposit a large sample was tested.

This clay worked up with 25 per cent of water to a mass of good plasticity, and 8.3 per cent air shrinkage. The average tensile strength was 95.1 pounds per square inch.

The fire tests of the soft-mud bricklets were as follows:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	18.9
05	1.7	15.1
03	2.4	14.2
1	2.4	13.92

The clay burned red, and the bricklets had a good ring even at Cone 010, but an excellent one at Cone 05. They were nearly steel hard at Cone 010, and completely so at Cone 03. Dry pressing was also tried, but on account of the fine silty character of the material it did not work very well.

A large sample was put through the stiff-mud machine, but difficulty was encountered in getting it to flow through the die without cracking, and it worked best when treated with the minimum quantity of water. There seems no doubt that it could be made into a good common brick by the soft-mud process, but there is some question as to whether it could be molded stiff mud.

About one-half mile further to the northeast is another exposure of residual clay (Lab. No. 2008), but the weathering here does not appear to be so deep as at the preceding locality. The clay from this locality is very gritty, but fairly plastic. On account of its grittiness it has a low air shrinkage of 4.4 per cent. It burns to an excellent brick with a good ring even at Cone 010, and is nearly steel hard also at this temperature. The fire shrinkage at Cone 010 is low, namely, .7 per cent, and the absorption is moderate, 15.8 per cent. At Cone 05 the fire shrinkage is 7 per cent, and the absorption 4.7 per cent. The material gives promise of making a good brick for general use.

Brandy.—Additional exposures of Triassic clay are to be found around Brandy, but one of the best is at the summit of a hill on the road, 1.5 miles northeast of town, and not more than half a mile in a direct line from the railroad.

The clay (Lab. No. 2009) is well located for working, and the tests given below indicate the possibility of using it. It gives a mass of good plasticity, but high air shrinkage, namely, 11.4 per cent. The clay burns to a good red color, and has a good ring even at Cone 010, becoming steel

hard at this cone. The fire shrinkage and absorption at Cone 010 were, respectively, 3.3 per cent and 22.4 per cent, while at Cone 05 they were 6.4 per cent and 15.6 per cent. The material could be used in brick manufacture, but it would be desirable to mix it with another clay of lower air shrinkage.

Culpeper.—Southeast of Culpeper on the road to Stevensburg there are a number of good exposures of Triassic clays. The best ones are nearest to Culpeper, and the material appears to be very similar to No. 2013, from the Elkwood-Culpeper road.

Stevensburg.—J. W. Legg has a brick and tile yard at this locality, which is intermittently operated, being idle at the time of our visit. The deposit which adjoins the yard is located on higher ground than the surrounding country, but it is probably derived from the Triassic, although it may have been reworked slightly by washing action.

This material (Lab. No. 2023), though of high plasticity, required only 20 per cent of water for mixing, and had an air shrinkage of 7 per cent. It burns to a bricklet with good ring and red color even at Cone 010. At this cone the fire shrinkage was 1.3 per cent, and absorption 11 per cent, while at Cone 05 the fire shrinkage was the same, and the absorption 9.1 per cent.

The clay can be used for common brick and drain tile, and Mr. Legg's yard is equipped with rolls, auger machine for brick and tile, and one circular, updraft kiln.

ORANGE COUNTY.

Orange.—A large, lens-shaped area of Triassic lies west of Orange, and extends, from a point 2 miles north, southward to Gordonsville. While the depth to bedrock seems to vary, there are evidently a number of points where it is possible to get a sufficiency of clay. The Triassic rocks in this area consist of conglomerate, sandstone, and shale, with some volcanics, and the residual clay derived from these may therefore be expected to vary somewhat.

Thus following the wagon road westward from Orange, and parallel with the railroad, a number of Triassic exposures are to be seen. One of these is about 2¼ miles from Orange on the Liberty Mills road, the bank being 12 feet high, and not far from the railroad. The material (Lab. No. 2001) is dark red gritty clay, and not used. It has fair plasticity, required 33 per cent of water for mixing, and has a rather high air shrinkage of 10 per cent. It burns to a fair brick of red-brown color at

Cone 010, with a fire shrinkage of 1 per cent, and an absorption of 21.7 per cent, which is rather high. At Cone 05 the brick is steel hard, with a good ring, 4 per cent fire shrinkage, and 15.3 per cent absorption.

The material could be used for common brick, and could probably be mixed up with less water, so as to reduce the air shrinkage.

About three-fifths of a mile east of Liberty Mills the Triassic still outcrops, but the clay here is more gritty. The interesting feature of this clay (Lab. No. 2002) is that it is residual from conglomerate. While the pebbles are pretty well decomposed, the clay is nevertheless somewhat gritty. The plasticity is fair and the air shrinkage 8.7 per cent. It gave a fair bricklet at Cone 010, of brownish-red color, and, while hard enough for use, the clay did not actually become steel hard until above Cone 05. At Cone 010 the fire shrinkage was 1 per cent, and absorption 18.8 per cent, while at Cone 05 these two values were, respectively, 1.6 per cent and 17.4 per cent. The material should work for common brick.

The decomposed conglomerate is exposed again in a new cut of the Southern Railway southwest of Montpelier. At Montpelier station there is a shallow cut in decayed conglomerate, which is more decomposed than any of the others, and consists of yellowish clay above. A large sample (Lab. No. 2003) was tested from this locality, as the exposure of material was good, and the general character is similar to No. 2002.

The plasticity developed by mixing with 30 per cent of water was fair, the average air shrinkage 7 per cent, and the average tensile strength, when air dried, 69 pounds per square inch. The soft-mud bricklets yielded the following results:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	Too soft for brick	....
05	2.7	16.3
1	3.0	16.8

The clay gives a fair brick at Cone 05, but the color is not a good red. At Cone 1 it is steel hard. A dry-press bricklet was tried, but did not yield a sound enough body.

A sample of the clay was then put through the stiff-mud machine, and flowed through both the brick and hollow-brick dies without any trouble. It would be necessary, however, to put the clay through a rolls before molding in order to crush the pebbles, as these would interfere with the cutting wires. The bricklets made from the stiff-mud mixture were a

little more absorbent at Cone 010, but showed the same absorption at Cone 03 as the soft-mud bricklets at Cone 1.

This clay could be used, we believe, for the manufacture of both common and hollow brick. It does not burn dense enough for drain tile.

PRINCE EDWARD COUNTY

Farmville.—There is evidently considerable Triassic clay in the vicinity of Farmville, and some of it was used a number of years ago for making brick. One of the best exposures is at the end of Ely Street, where an excavation has been made by Thos. A. Bolling for making brick. The clay is red and plastic near the surface, but about 3 feet down shows considerable mica. The material (Lab. No. 2039) is well located for transportation, and hence a large sample was tested.

The clay shows considerable sand and mica, the small scales of the latter being noticeable in the burned brick. With 36 per cent of water the clay worked up to a mass of fair plasticity, whose average air shrinkage was 6 per cent, and average tensile strength 90.4 pounds per square inch.

The fire tests on the soft-mud bricklets resulted as follows:

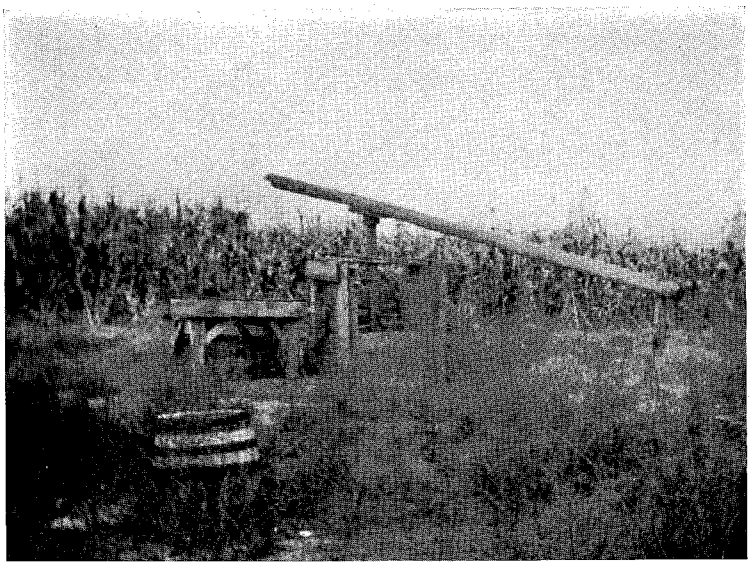
Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.0	23.1
05	4.0	17.9
03	5.0	15.1

The clay burns to a red color, with a fair ring at Cone 010, and a good ring at Cone 05. It became steel hard at Cone 03. The material can be considered suitable for common brick, although the absorption is a little higher than desirable at Cone 010. Attempts to mold the bricklets dry press did not yield encouraging results.

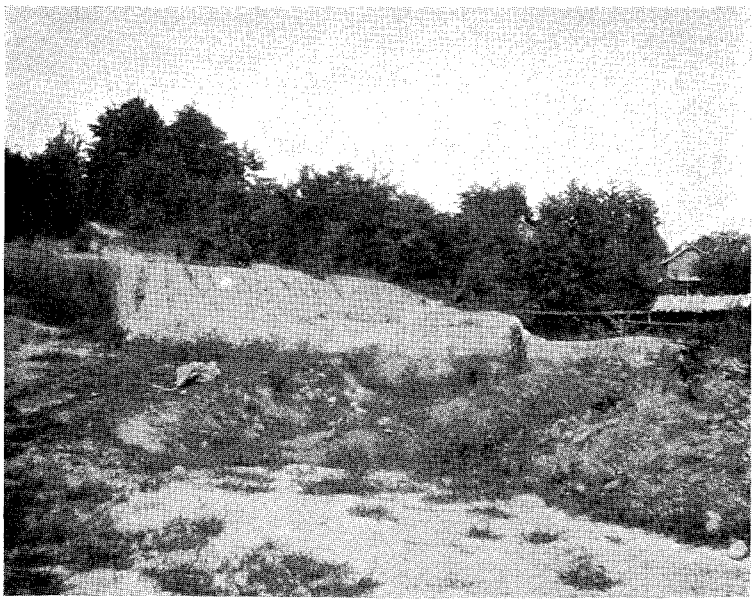
Bolling's yard was equipped with a soft-mud machine, operated by horse-power. The product, which was burned in scove kilns, was not fired hard enough.

On High Street, 1 mile northwest of town, a blue-gray, very sticky clay is to be found. It is probably residual from shale or shaly sandstone, and there is an exposure of it about 100 feet long and 8 feet high, without any bedrock showing.

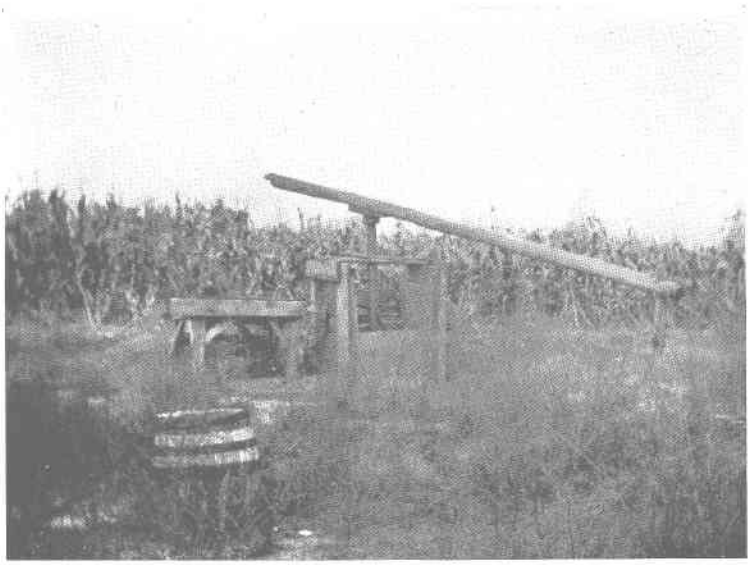
As the tests show, it (Lab. No. 2073) is a good brick material, and though from the same formation, it yields results quite unlike those obtained on testing No. 2039, and is of better grade.



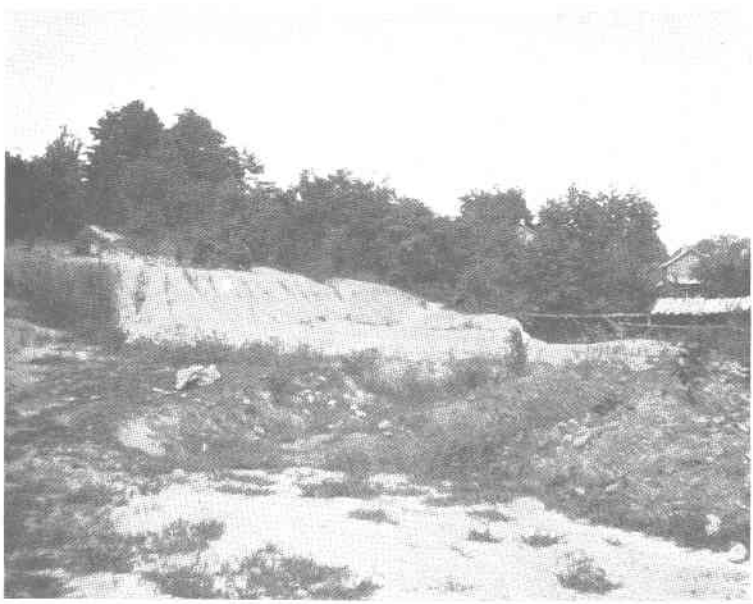
(A) Horse-power pug mill, Bolling's yard, Farmville.



(B) Clay bank, Ivey's brickyard, Chatham.



(A) Horse-power pug mill, Bolling's yard, Farmville.



(B) Clay bank, Ivey's brickyard, Chatham.

The clay worked up with 24 per cent of water to a mass of good plasticity, whose air shrinkage was 5.1 per cent, and average tensile strength 131.7 pounds per square inch. It was tested both by molding soft mud, and by running it through the stiff-mud machine.

The soft-mud tests were as follows:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.3	16.4
05	.3	16.2
03	1.3	11.7
1	1.7	11.0

These bricklets show a low fire shrinkage, and moderate absorption. They were steel hard at Cone 03, but had a fair ring even at Cone 010. At this cone the color was light red, but deepened at Cone 05.

A sample was put through the stiff-mud machine, and flowed easily through the brick die without cracking. There are scattered pebbles in the clay, which would have to be eliminated by means of a rolls. The product from this machine gave a fair brick at Cone 010. This clay could be used for common brick, and might even work for hollow brick.

HALIFAX COUNTY.

Wolftrap.—There is a small elliptical area of Triassic, about 8 miles long, lying north and west of the railway in this vicinity, while a second area of about the same size lies 24 miles to the north in Charlotte County.

One mile northeast of Wolftrap station there is an excellent section of the Triassic in the railroad cut. The material exposed is a smooth, brownish-red shale, which grinds up easily, and in its upper part is completely weathered to a plastic clay. This clay underlies the field and slopes to the west of the track, and has there been utilized for making common brick by the Boston Brick Co. They have not employed any of the shale, as the residual clay has thus far been sufficient for their needs.

The product now being made from the clay consists of common brick, the plant being equipped with a disintegrator, rolls, pugmill, end-cut, stiff-mud machine, and dryer.

The shale deposit is the most important material to consider here, for it represents one of the best deposits of plastic materials seen in the Piedmont Plateau region. This is a smooth, brownish-red shale (Lab. No. 2037) that worked up to a mass of excellent plasticity with 35 per cent of water, and 10 per cent air shrinkage, which is too high and would have

to be reduced, probably by adding some of the neighboring sandy residual soil. The average tensile strength was 200 pounds per square inch.

On testing the soft-mud bricklets the following results were obtained:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	2.0	22.4
05	4.0	17.1
03	5.7	8.90
1	6.0	7.00

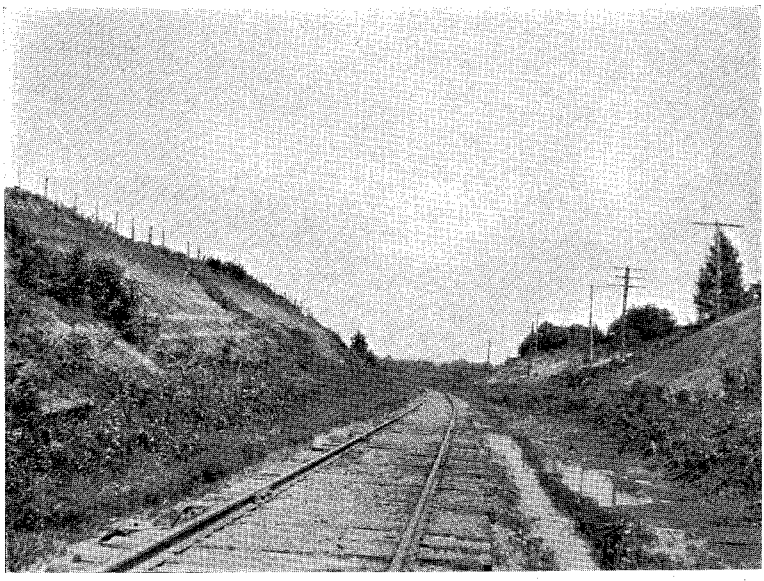
The clay burns to a red color, has an excellent ring even at Cone 010, and is steel hard at Cone 03. A sample tested in the stiff-mud machine worked well in both the brick and the tile dies, and gave a good hard product.

The shale could probably be used for common brick, hollow brick, and drain tile. It would also work for dry-press brick. Indeed it is one of the best clays tested from the Piedmont region.

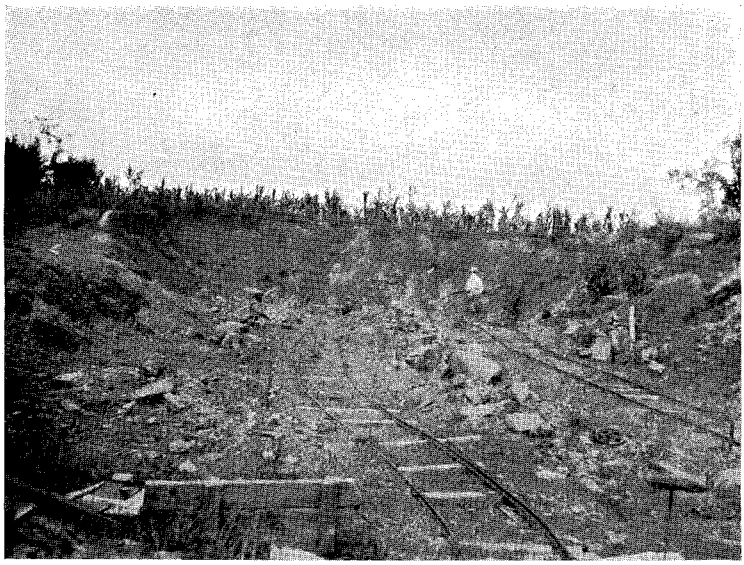
PITTSYLVANIA COUNTY.

Leaksville Junction.—The Triassic shale at this locality is quite different from the Wolftrap material, for it is exceedingly gritty, and is interstratified with occasional beds of sandstone, which have to be thrown out in quarrying the shale.

The shale is hard and does not grind readily, moreover it possesses low plasticity, and the fact that it could be worked is due to the loamy overburden being mixed with it. As the cut becomes deeper, there would not be enough of this to mix with the shale. So, on the whole, unless enough clay is available to mix with the shale, it is not to be regarded as a very desirable proposition.



(A) Triassic shale in cut, one mile north of Wolftrap.



(B) Triassic shale at brick works near Leaksville Junction.

(A) Triassic shale in cut, one mile north of Wolftrap.

(B) Triassic shale at brick works near Leaksville Junction.

SUMMARY OF TESTS OF TRIASSIC CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2020	Calverton	30.0	Fair	8.0	.....	0.3	17.3	4.3	10.1	.....	.....	.....	.....
2021	Calverton	20.0	Fair	4.9	.....	1.0	18.9	6.3	8.4	.....	.....	.....	.....
2013	Culpeper	25.0	Good	8.35	95.15	0.0	18.9	1.7	15.1	2.4	14.2	2.4	13.92
2008	Culpeper	45.0	.....	4.4	.....	0.7	15.8	7.0	4.6	.....	.....	.....	.....
2009	Brandy	49.0	Good	11.4	.....	3.3	22.4	6.4	15.6	.....	.....	.....	.....
2023	Stevensburg	20.0	High	7.0	.....	1.3	11.0	1.3	9.1	.....	.....	.....	.....
2001	Orange	33.0	Fair	10.0	.....	1.0	21.7	4.0	15.3	.....	.....	.....	.....
2002	Orange	36.0	.....	8.7	.....	1.0	18.8	1.6	17.4	.....	.....	.....	.....
2003	Montpelier	30.0	Fair	7.7	69.01	.....	.....	2.7	16.3	.....	.....	3.0	16.9
2039	Farmville	37.0	Fair	6.0	90.4	1.0	23.1	4.0	17.9	5.0	15.1	.....	.....
2073	Farmville	24.0	Good	5.1	132.0	0.3	16.4	0.3	16.2	1.3	11.7	1.7	11.0
2037	Wolftrap	35.0	Good	11.5	200.0	2.0	22.4	4.0	17.1	.....	.....	6.0	7.0

Comments on the Table.

The Triassic clays show a variable amount of water required for mixing, but the quantity is not always high. The plasticity is fair to good, and the air shrinkage is variable, but in most cases not too high for use. It is to be especially noticed that not a few of the shales burn to a fairly dense body at Cone 05. While all the clays make common brick, the absorption at Cone 010 is at times rather high. Certain ones like those tested from Farmville, Montpelier, and Wolftrap would do for the manufacture of hollow brick. The Wolftrap material is also suited for the manufacture of drain tile and dry-pressed brick.

ORDOVICIAN CLAYS.

PRINCE WILLIAM COUNTY.

Quantico.—Six miles west of Quantico Station, near Dumfries, is the Cabin Branch pyrite mine. The pyrite body is enclosed between schists, which are weathered on the outcrops. In putting down a new shaft at the mine 18 feet of residual clay were passed through, and then 60 feet of what appeared to be disintegrated biotite schist. The material was fairly solid when thrown on the dump, but crumbled readily to a mass that resembled clayey sand.

As the question was raised whether this material would do for brick manufacture, a large sample (Lab. No. 2022) was put through some physical tests. The material is a dark gray, sandy clay of slight plasticity, and 5 per cent air shrinkage. The average tensile strength was 67 pounds per square inch.

The chief difficulty with the material is its low plasticity in the raw state. But in burning the soft-mud bricklets had a body at Cone 010 that was surprisingly solid and gave a fair ring, although the clay did not actually burn steel hard until Cone 03.

The firing tests gave the results shown below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.6	26.3
05	2.0	22.2
03	3.0	8.6
1	4.3	8.4

The clay burns reddish and is steel hard at Cone 03, but has a fair ring at Cone 010; and, while it is by no means an ideal brick material, it could be used if necessary.

(A) Clay overlying slate, north of Arvonia.

(B) Section showing sharp contact between clay and slate shown in view above.

(A) Clay overlying slate, north of Arvonia.

(B) Section showing sharp contact between clay and slate shown in view above.

BUCKINGHAM COUNTY.

Arvonia.—The Ordovician slates at this locality have been actively worked for many years for roofing purposes, but as usual the amount of waste is very large, accumulating in dump piles of considerable size, for which there is no use at the present time. The problem that presented itself here, therefore, was to determine whether the slate refuse could be used for common-brick manufacture.

The fresh slate, even if finely ground, has too little plasticity to permit its being molded, so we have the possible alternative of mixing the slate with clay, the latter representing the residual material derived from the weathering of the slate.

An examination of a number of quarries in the district showed that the depth and extent of weathering is exceedingly variable. Thus at the Williams quarry near the station there is very little weathered rock, while at the Pitts and LeSueur quarries the slate though hard is slightly weathered to a depth of 15 to 30 feet, and it is claimed that this material can be used for making dry-pressed brick. On the other hand at the quarry of the Arvon Slate Co., 2 miles south of Arvonia, and at Ferncliff, 2 miles north of Arvonia, plastic, residual clay overlies the slate.

In order to get some definite information of the possible use of the slate for clay products, several samples were collected and tested.

The first investigated was the slate of Williams quarry, which was mixed with clay from a cut along the railroad about a quarter of a mile north of Arvonia. This is a tough, ferruginous clay resting directly on the slate, but sharply separated from it. The clay is usually quite plastic, but in places it is loamy or sandy, and contains rounded quartz pebbles. It is probably a colluvial clay, and the exposure is about 400 feet long and 8 to 10 feet deep.

A mixture (Lab. No. 2101) was made up of 75 per cent slate refuse ground to pass through an ⅛-inch crusher opening, and 25 per cent of the clay from one mile north of Arvonia. Some of the slate became rather finely crushed in putting it through the crusher. This mixture worked up to a fairly plastic mass with 18 per cent water, whose air shrinkage was 1.7 per cent, and average tensile strength about 25 pounds per square inch.

It was possible to mold it into bricklets without any difficulty, and these became steel hard, deep red in color, and had a good ring if fired to Cone 05.

The other firing tests were:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	14.3
05	0.0	13.5
1	0.0	10.8

The very low fire shrinkage, due to the gritty character of the slate, is quite noticeable, but the clay which fills in the voids keeps the absorption low. If desired, it would be perfectly possible to use this mixture for brick making, and the rough slate grains scattered through the clay would help to roughen the surface, if the mixture were used for making rough-texture brick.

At the quarry of the Arvon Slate Co., already referred to, the residual clay shows in the quarry above the slate, and also in the slope to the west of the quarry where several prospect trenches have been dug. One of these is 3 feet deep and all clay; the other is 9 feet deep and mostly clay, there being some partly-weathered rock in the bottom.

The residual clay from the 3-foot trench (Lab. No. 2103) is smooth and plastic, and worked up with 35 per cent of water. The air shrinkage was 8 per cent. The clay burns to a good color, but not to a very dense body. Thus at Cone 010 the fire shrinkage and absorption were, respectively, 1 per cent and 27.9 per cent, while at Cone 05 they were 3.4 and 24.8 per cent. So while this particular part of the deposit gives a sound brick, at a low heat, the product is very porous.

Comparing the above with another sample (Lab. No. 2104) from the 9-foot trench on the same property, and including a little partly-weathered slate in the sample, we find some interesting differences. This mixture is smooth and plastic, but required only 30 per cent of water to work it up, and had an average air shrinkage of only 2.4 per cent. The average tensile strength was low, being not over 10 pounds per square inch. The bricklets had a good ring at Cone 05, and an excellent one at Cone 03. They burn to a red color. The other firing tests were as follows:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	Too soft to use	....
05	.7	24.0
03	2.7	17.2
1	4.0	15.8

The clay should be burned to Cone 03 to give a good brick, and if there is a sufficient quantity of the clay it could be employed for this purpose.

The variation in the character of the material could be adjusted by using a mixture from different parts of the deposit.

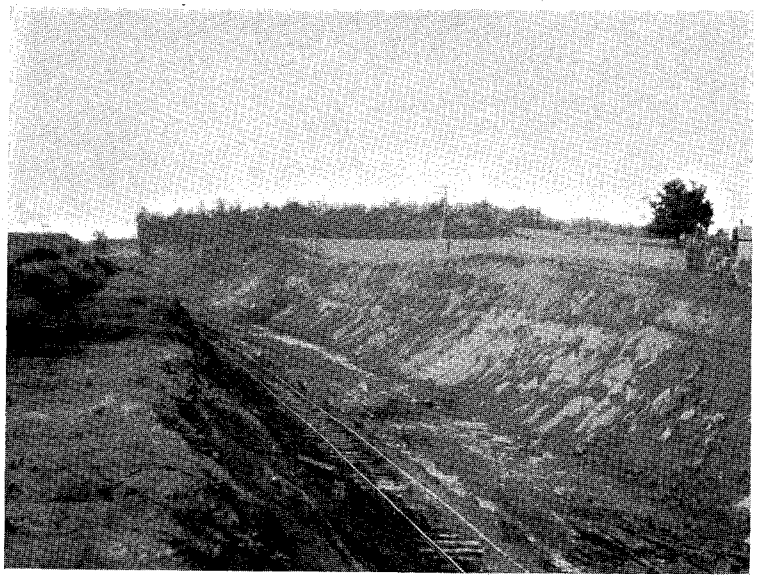
The slightly weathered slate (Lab. No. 2106) from the LeSueur quarry was also tried out. This when ground up is of too low plasticity to mold. It can be dry pressed, if care is used, but it takes too much care for commercial purposes. The best way to treat this would be to mix it with a little plastic clay.

At Ferncliff, north of Arvonia, the gullies on the hillside above the quarry indicate rather widespread residual clay, but our actual knowledge of its depth does not exceed 3 feet.

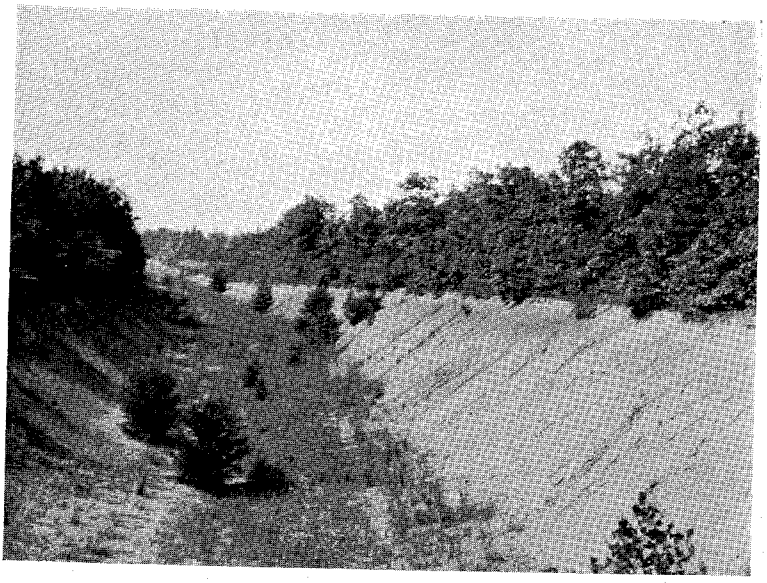
The decayed schists along the main road between Arvonia and Bremo Bluff do not offer much promise.

SUMMARY OF TESTS OF ORDOVICIAN CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2101	Arvonia, slate and clay.....	18.0	Fair	1.7	Less than 25.0	0.0	14.3	0.0	13.5	.....	.....	0.0	10.8
2103	Residual clay, Arvon Slate Co.....	35.0	.....	8.0	.....	1.0	27.9	3.4	24.8	.....	.....	.....	.....
2104	Clay and weathered rock, Arvonia...	29.8	Good	2.4	Less than 10.0	.....	.....	0.7	24.0	2.7	17.2	4.0	15.8
2106	LeSueur quarry.....	30.7	Low	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
2105	Ferncliff quarry	46.0	Good	10.8	.....	2.7	30.8	5.4	25.2	.....	.....	.....	.....



(A) New cut on Southern Railway near Orange.



(B) Old cut near City Farm station, southeast of Lynchburg. Residual clay from rocks of Cambrian age.

(A) New cut on Southern Railway near Orange.

(B) Old cut near City Farm station, southeast of Lynchburg. Residual clay from rocks of Cambrian age.

Comments on the Table.

The residual clays from the slate can be used for making brick. The best results were obtained by using ground slate waste from the quarries and the clay found north of Arvonia, a mixture that should work well for rough-textured brick.

CAMBRIAN CLAYS.

The Cambrian formations occupy rather narrow belts in the western part of the Piedmont region. (See map, Plate I, in pocket.) These belts, which coalesce to form one south of Charlottesville, extend all the way across the State. The rocks from which the residual clays are derived are chiefly schists. The clays are not as important as those from the other formations, partly on account of their location, and partly because they do not always burn to as good a brick as the other clays.

Residual clays derived from the Cambrian rocks were tested at some six different localities discussed below.

ORANGE COUNTY.

Orange.—There is a considerable quantity of residual clay from the Cambrian to be found around Orange, but none of it is being used at the present time. The best exposures are in two large cuts along the new line of the Southern Railway about one mile west of Orange. The second cut shows red and brown residual clay, with a maximum exposed depth of 40 feet. The clay is soft and plastic when wet, but not very sticky, and there are many slicken-sided surfaces coated with limonite. Numerous cross joints, emphasized by streaks and films of limonite, cut through the clay. No solid rock shows in the cut.

The material (Lab. No. 2004) is residual clay derived from gneiss. It has fair plasticity, but takes considerable water to mix, namely, 43 per cent. The air shrinkage is low, 3.3 per cent, and so is the average tensile strength, which does not exceed 10 pounds per square inch.

The soft-mud bricklets burned to a bright red color, and, while they were not hard enough at Cone 010, gave a fair product at Cone 05.

The other firing tests were as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
05	4.6	37.0
03	5.3	37.0
1	5.3	35.6

The main objection to the bricklets is their very high absorption. A large sample tested in the stiff-mud machine worked through the die without any trouble.

While the material could be utilized for the manufacture of common brick to be used in small structures, a denser and harder-burning clay is desirable.

Following across the Cambrian from Orange to Madison Run, there are many outcrops of bedrock, and occasional cuts in residual clay, much of which is similar to that in the large cut previously mentioned.

About three-quarters of a mile northeast of Madison Run, the phyllites are decomposed to a moderately plastic clay (Lab. No. 2005). Other shallow exposures are to be seen northwest of Madison Run station, and not far from the station is an old church built before the war of brick made from the local clay. Most of these are still in good condition.

A few tests made on the clay derived from the phyllite are given below. This clay (Lab. No. 2005), though derived from the same formation but a more schistose rock than No. 2004, is quite contrasted to it so far as tested. Though gritty, it has fair plasticity, and took 38 per cent of water to develop it. The air shrinkage was 8.2 per cent. At Cone 010 the soft-mud bricklets had a fire shrinkage of 2 per cent, and an absorption of 20 per cent, while at Cone 05 these were 6.4 per cent and 12.20 per cent, respectively. The bricklets had a good ring at Cone 05, although the product could be burned at a slightly lower temperature. The color after burning is red.

Judging from these tests, this clay should make a much better brick than the preceding one.

Additional good exposures of Cambrian residual clays are found along the Southern Railway, about half a mile north of Orange. The clay is red on the surface, but yellowish below, and is quite sticky.

A very red sticky clay was formerly worked by Hatcher and Gaither near Orange, but the product, due partly to insufficient burning, was not very hard. No brick have been made since 1912.

Gordonsville.—Cuts in Cambrian residual clays are numerous to the southeast of Gordonsville, but few of them are deep. The material exposed in them, however, exhibits considerable similarity.

The best cut seen is located about 2¼ miles southeast of town on the road to Mechanicsville, and shows a section of residual clay about 8 feet

deep derived from schist. The upper part of the section is thoroughly weathered, but the lower third still shows the schistose structure of the parent rock. There are scattered veinlets of quartz, but on the whole the material is sufficiently plastic to mold as shown by the following tests.

The material (Lab. No. 2095) is a smooth red clay, which worked up with 39 per cent of water to a mass of good plasticity, whose air shrinkage was 8.3 per cent, and average tensile strength 65 pounds per square inch. The soft-mud bricklets burned to a good red color, but did not give a good ringing product unless burned to at least Cone 05, and became steel hard at Cone 03. The fire shrinkage is not high, but a desirably low absorption was not obtained unless burned to Cone 1, although that noted at Cone 010 is not higher than that of many of the common brick now made in the Piedmont.

The fire tests made on the soft-mud bricklets are tabulated below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	26.7
03	2.7	28.4
1	3.7	18.7

A sample tested in the stiff-mud machine flowed through the brick die without any difficulty. The clay contains some stony lumps, however, which must be broken up before it is put through the machine. This clay is to be classed as a fair common-brick clay.

Other Cambrian clays are found to the northwest of Gordonsville. Thus on the Barboursville road, about a third of a mile northwest of town, there is a section about 200 feet long, with a maximum depth of 10 feet. The clay is at times stony, but the pebbles were broken up in grinding the sample. The latter was taken from the top to the bottom of the cut.

The clay (Lab. No. 2080), although sandy to the feel, and moderately plastic, should be useful for common-brick manufacture. Its air shrinkage after mixing with 35 per cent of water is 7.9 per cent. The bricklets burned to a good red color, and had a good ring even at Cone 010, although the absorption was rather high. The fire shrinkage and absorption at Cone 010 were, respectively, .7 and 26.4 per cent, and at Cone 05, 3, and 19.2 per cent.

A little further west on the same road is another cut, 150 feet long with a maximum depth of 12 feet. Similar clay shows in the hills around this point, and so it was thought desirable to sample it. The tests show it to be a red, smooth clay (Lab. No. 2084) of high plasticity, which when

worked up with 39 per cent of water had an air shrinkage of 8.3 per cent, and a tensile strength of 49 pounds per square inch.

The clay differs somewhat from many of the other samples tested, for while it maintains a good red color up to Cone 03, above that it darkens, shrinks, and cracks so badly as to be worthless. Below the temperature mentioned the color and ring are good, although the bricklets at times cracked a little. It was steel hard at Cone 05.

Other firing tests are as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	2.3	22.8
05	4.0	19.4
03	8.3	5.85
1	11.0	5.9

The clay would probably work in a stiff-mud machine. It could be used for brick manufacture. These residual clays from Cambrian show at other points along the road nearly to the base of Southwest Mountain.

ALBEMARLE COUNTY.

Charlottesville.—Residual clays derived from the Cambrian schists and the Catoctin schist (altered basalt) of pre-Cambrian (Algonkian) age occur, but the clays derived from the Cambrian rocks are the only ones that have thus far been utilized in the manufacture of common brick. Of the two brick plants recently operated at Charlottesville, only one is running at present.

Keswick.—The bedrock around Keswick is schistose and slaty, and there are but few exposures of clay within a mile of the town.

One found about a quarter of a mile southwest of Keswick was put through a few tests. The material (Lab. No. 2085) from here is a dark brown, sandy clay, with good plasticity. The addition of 30 per cent of water gave a workable mass whose average air shrinkage was 5.6 per cent, and at Cone 05 it gave a good brick. The fire shrinkage and absorption at Cone 010 were 1.3 and 24.4 per cent, respectively, while at Cone 05 they were 2.3 and 19.7 per cent.

Although the absorption is a little high, there is no objection to employing this material for common-brick manufacture.

CAMPBELL COUNTY.

City Farm Station.—In an abandoned cut of the Southern Railway there is one of the best exposures of residual clay from the Cambrian rocks that we investigated. The section is about 20 feet thick, and the clay appears to be derived from schist, but on account of slide material it was not possible to section the full thickness of the deposit.

Of the two following samples, No. 2026-7 represents the upper 8 feet, and No. 2075 the next lower 4 feet. The clay from the upper part of the cut (Lab. No. 2026-7) is red-brown and fairly plastic. Its air shrinkage was 7 per cent, and average tensile strength not over 15 pounds per square inch. At Cone 010 it was too soft for a good brick, but at Cone 05 while hard enough the absorption was too high, namely, 31.6 per cent. This high porosity was accompanied by an almost negligible fire shrinkage.

The material from lower down in the cut (Lab. No. 2075) was very similar, for while its air shrinkage was a little lower, 5.2 per cent, the absorption at Cone 05 was also high, 30.6 per cent, and the fire shrinkage very low.

These clays could be used for common brick, but materials with lower absorption and denser-burning qualities should be sought.

Lynchburg.—The only locality near Lynchburg, where the Cambrian has been worked, is at the plant of the DeWitt brick works, 2 miles west of Lynchburg, on the Norfolk and Western Railway.

The material (Lab. No. 2099) appears to be residual from a schist, but the deepest lies on a hill slope, and may have been moved somewhat by slide, as well as being reworked a little by water. Scattered through it are schist fragments.

The clay is fairly plastic, and required 38 per cent of water to work it up. The air shrinkage was 8.7 per cent, and the average tensile strength 69 pounds per square inch. The bricklets after burning had a good red color, but did not develop a good ring unless burned to Cone 05. The absorption is moderate above Cone 05.

The fire shrinkage and absorption, at the several cones, were as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.0	26.7
05	.0	25.1
03	2.4	16.4
1	4.4	16.9

A second lot was tested in the stiff-mud machine, but could not be made to flow through the die without tearing badly. The material could be used for common brick, if molded in a soft-mud machine, but it must be well burned to give a marketable product.

Altavista.—No bricks are now made at this locality, but there is an abandoned brickyard on the south side of the Virginian Railroad, about a quarter of a mile northeast of the town. The clay (Lab. No. 2056) is residual from schist, and has been excavated to a depth of 4 to 6 feet, the upper part being quite uniform, but becoming mottled with depth. No bedrock was struck, and we do not know how deep the deposit is.

The clay is of good plasticity, with an air shrinkage of 7.9 per cent. It burns to a red brick, and has a sound ring even at Cone 010.

The fire shrinkage and absorption at different cones are given below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.7	25.9
05	1.7	23.4
03	5.0	15.0
1	5.0	15.8

These tests show low fire shrinkage up to Cone 05, with rather strong absorption, but above that a moderate fire shrinkage with only moderate absorption.

The clay should work for a common brick, but the yard ceased operations about two years ago, although the location is an excellent one, and there seems no reason why the clay should not make a salable product if properly handled.

SUMMARY OF TESTS OF CAMBRIAN CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2004	Orange	43.0	Fair	3.0	Less than 10.0	1.0	.....	4.6	37.0	5.3	37.0	5.3	35.6
2005	Madison Run	38.0	Good	8.2	.....	2.0	20.0	6.4	12.2	.....	.....	.....	.....
2095	Gordonsville	39.0	Good	8.3	65.0	0.0	26.7	.....	.....	2.7	28.4	3.7	18.7
2080	Gordonsville	35.0	Fair	7.9	.....	0.7	26.4	3.0	19.2	.....	.....	.....	.....
2084	Gordonsville	39.0	High	8.3	49.0	2.3	22.8	4.0	19.4	8.3	5.8	11.0	5.9
2085	Keswick	30.0	.....	5.6	.....	1.3	24.4	2.3	19.7	.....	.....	.....	.....
2026-7	City Farm Station	45.0	Fair	7.0	Less than 15.0	0.0	.....	0.0	31.6	.....	.....	.....	.....
2075	City Farm Station	39.0	Fair	5.2	.....	0.3	.....	1.0	30.6	.....	.....	.....	.....
2099	Lynchburg	30.0	Fair	7.9	.....	0.3	27.1	2.0	25.0	.....	.....	.....	.....
2056	Altavista	.....	Good	7.9	.....	0.7	25.9	1.7	23.4	-5.0	15.0	5.0	15.8

Comments on the Table.

The residual clays derived from the Cambrian rocks usually required a considerable amount of water for mixing, and had at least fair plasticity. The air shrinkage is variable, and not directly related to the amount of water required. The fire shrinkage was low at Cone 010, but variable at Cone 05. The absorption of all was rather high at Cone 010, but with some it decreased considerably at Cone 05. The Cambrian clays can nearly all be used for the manufacture of common brick, but they are the least desirable of any of the classes of residual clays tested, for the reason that most of them burn to a very porous body. This is due in part at least to their micaceous character.

ALGONKIAN CLAYS.

Reference to the map, Plate I, will show the extension southwestward from Maryland into Virginia of two approximately parallel but irregular narrow belts of dark basic igneous rocks (basalt and diabase) of pre-Cambrian (Algonkian) age, and designated Catoctin schist. The rocks of these two belts have been more or less altered by metamorphism into chlorite and epidote aggregates, and are schistose in character.

The more westerly of the belts is confined to the Blue Ridge Mountains, and extends southwestward from the Potomac almost to the James. The second belt extends from north-central Loudoun County southwestward to a point south of the central portion of Albemarle County. Warrenton and Culpeper are located on this belt, while Orange and Gordonsville are situated only a short distance east of it, and Charlottesville lies on the western margin not far from its southernmost extension.

The Catoctin schist yields normally a highly ferruginous dark red clay which can be used for brick manufacture, but it seems to be inferior to that derived from some of the other formations.

FAUQUIER COUNTY.

Warrenton.—The region around Warrenton is underlain by Catoctin schists, but there are comparatively few exposures of clay, in spite of the hilly character of the region. Such cuts as there are appear chiefly along the high roads.

From these road-cut sections it would appear that the character of the schists is variable, and consequently also the character of the residual clays. Where the bedrock contains more or less biotite and feldspar it seems to

give rise to a tough, often plastic clay, but in other places, as on the north side of Baldwin's Ridge and on the New Baltimore turnpike, the schist contains so much muscovite and quartz as to weather to a light-colored, very sandy clay, known locally as sand, and of no use in brickmaking. All the bricks used in Warrenton come from Alexandria.

One sample was tested from the vicinity of Warrenton. This was collected about 2 miles northeast of town, on the road from Auburn to the New Baltimore turnpike; and, while the location is not favorable for a brick plant, the material represents the better type of clay to be found in this vicinity.

The clay (Lab. No. 2019) which is residual from diabase is of moderate plasticity, and, when mixed up with 36.6 per cent water, had an air shrinkage of 6.4 per cent, and an average tensile strength of 71 pounds per square inch. It burned to a good red color, and was steel hard with a good ring at Cone 03, although even at Cone 05 it would probably be hard enough for common brick. The absorption below Cone 03 is a little higher than is desired, but at the last-named cone is not excessive.

The other fire tests on the soft-mud brick follow:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	2.3	27.0
05	3.0	23.5
03	4.4	18.11
1	6.0	17.70

A sample tried in the stiff-mud machine ran through the brick die fairly well, although at times it showed a tendency to crack, but this may have been due to the fact that the die was not thoroughly adapted to this type of clay. The material did not dry-press successfully. It is to be classed as a red-burning brick clay.

Another sample (Lab. No. 2025) taken from a small cut south of Warrenton was fairly plastic, had 5.6 per cent air shrinkage, and, while the bricklet at Cone 010 was fair, the absorption was very high, namely, 30 per cent.

CULPEPER COUNTY.

Culpeper.—The residual clays from the Catoctin schist are found in limited amounts west of Culpeper, especially to the southwest on the road towards Fordville. But while clays are not scarce, there are few large outcrops. The best was seen about a mile southwest of Culpeper, where a bank about 75 feet long can be examined. There is not enough material

here to warrant starting a yard, and a small sample (Lab. No. 2015) was put through a few tests, to compare with the other Catoctin clays. The results of these tests follow:

This material (Lab. No. 2015) was a yellowish-brown, gritty clay, which with 22 per cent of water gave a mass having 4.5 per cent air shrinkage. The few tests made on this sample indicate that it burns to a better body than most of the Catoctin clays tested, giving a fair bricklet at Cone 010, and a good one at Cone 05. The fire shrinkage at both cones mentioned is zero, and the absorption at Cone 010 is 18.5 per cent, and at Cone 05, 15.3 per cent. Material of this character should make a good brick.

A second sample was taken from a pit, where Mr. Clarke of the brick works is said to have obtained a trial load of clay. This deposit is near the creek, about a half to three-quarters of a mile west of town, and the material is probably of colluvial nature. It is a light brown, gritty clay (Lab. No. 2014), which worked up with 38 per cent of water, and had 11.3 per cent air shrinkage. One sample burned at Cone 010 showed zero fire shrinkage, and 27.8 per cent absorption. It is not to be recommended as a good brick clay. About 50 yards from this pit is another one of undoubted residual character.

About half a mile west of south from Culpeper is a residual clay, which seems to result from the weathering of a conglomerate made up largely of material derived from the Catoctin. There is an outcrop about 200 feet long and 6 feet high. The material is a red, slightly gritty clay (Lab. No. 2016), which took up 34 per cent water in mixing, and had an air shrinkage of 7.5 per cent. It burns red, but does not give a very hard product, the absorption even at Cone 05 being rather high.

Two miles southwest of Culpeper, the residual clay which may possibly be in the Cambrian is very micaceous and sandy (Lab. No. 2017). It is sufficiently plastic to mold, but does not yield very good results on burning.

Again, 1.5 miles southwest of Culpeper, there occurs a very sticky red clay, which appears to be very abundant. The material (Lab. No. 2018) takes 40 per cent of water to work it up, but gives a mass of excellent plasticity, whose air shrinkage is 7.2 per cent. It burns red-brown, but owing to the high porosity of the burned product does not give a very hard bricklet. Thus at Cone 010 the absorption was 34.4 per cent, while even at Cone 05 the absorption was 31.7 per cent, with a fire shrinkage of 3 per cent.

The material is a low-grade brick clay.

ORANGE COUNTY.

Gordonsville.—The Catoctin formation lies to the west of the railroad and separated from it by a narrow belt of Cambrian. A sample of it was obtained about 2 miles north of west from Gordonsville on the Barboursville road, and may be residual from diabase.

This clay (Lab. No. 2035) is red, smooth, and plastic. Thirty-eight per cent water gave a mass with moldable qualities, and 7.7 per cent air shrinkage. The burned product has a red color, and is fairly hard even at Cone 010, but shows a tendency to develop many small surface cracks. The absorption after burning is also high. Thus at Cone 010 the fire shrinkage and absorption were, respectively, 4.3 and 30.8 per cent, while at Cone 05 they were 6.4 and 27.7 per cent.

The material could be used for common brick, but is not the best obtainable.

SUMMARY OF TESTS OF ALGONKIAN (CATOCTIN SCHIST) CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2019	Warrenton	37.0	Not High	6.4	71.0	2.3	27.0	3.0	23.5	6.0	18.1	4.4	17.7
2025	Warrenton	50.0	Fair	5.6	.....	3.4	30.0	.....	.....	.....	.....	.....	.....
2014	Culpeper	38.0	Fair	5.6	.....	0.0	27.8	.....	.....	.....	.....	.....	.....
2015	Culpeper	22.0	Fair	4.5	.....	0.0	18.5	0.0	15.3	.....	.....	.....	.....
2016	Culpeper	34.0	Fair	7.5	.....	2.4	40.0	3.7	36.0	.....	.....	.....	.....
2017	Culpeper	36.0	Fair	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
2018	Culpeper	40.0	Good	7.2	.....	0.0	34.4	3.0	31.7	.....	.....	.....	.....
2035	Gordonsville	38.0	Fair	7.7	.....	4.3	30.8	6.4	27.7	.....	.....	.....	.....

Comments on the Table.

The chief features of these clays are the high amount of water required for molding, and their high absorption after burning. They can be used for brick-making, but most of them are too open burning, and if possible a clay that fires to a denser body should be chosen. No. 2015 from Culpeper forms a desirable exception.

PRE-CAMBRIAN VOLCANIC CLAYS.

These occupy a small area in the southern part of the Piedmont region, extending from north of Meherrin southwest to Virgilina. The rocks are more or less schistose, and weather to a ferruginous residual clay, which is often suitable for brick manufacture.

CHARLOTTE COUNTY.

Keysville.—There are not many exposures of clay in the pre-Cambrian volcanic area around Keysville, although where any are seen the material seems to be fairly plastic, but not over 3 or 4 feet deep.

LUNENBURG COUNTY.

Simplicity.—This town lies between Keysville and Meherrin, and in the Virginian Railroad cut at Simplicity station, the pre-Cambrian volcanics yield a residual clay from 3 to 4 feet deep. This is one of the few localities where a sample of this formation was obtainable.

The clay (Lab. No. 2062) is red, smooth, moderately plastic, working up with 41 per cent of water to a mass whose air shrinkage was 9.2 per cent. The clay burns red, with a good ring even at Cone 010, and is a good brick clay, even though the absorption of the bricklets is a little high. At Cone 010 the fire shrinkage was 3 per cent, and absorption 26.8 per cent. At Cone 05 the fire shrinkage was 2.7 per cent, with an absorption of 26 per cent. The bricklets were steel hard even at Cone 010.

Virso.—In this vicinity, too, we were able to obtain samples of the residuals of the pre-Cambrian volcanics. One of these was obtained from a cut a third of a mile west of Virso on the Virginian Railroad, the section being about 25 feet high. The bedrock is a light-colored schist, and the passage from bedrock to clay is rather abrupt.

The clay (Lab. No. 2048) is very smooth and plastic, and works up with 23 per cent of water to a body having 7.4 per cent air shrinkage. It burns to an excellent hard body, of low fire shrinkage, although not very

bright color, at Cone 010. The absorption, moreover, is not by any means high, so that the material recommends itself as a brick clay, or possibly even for other kinds of structural clay products. At Cone 010 the fire shrinkage and absorption were 0.3 per cent and 12 per cent, respectively, while at Cone 05 they were 1 per cent and 9 per cent.

Just west of Virso on the same railroad is a cut about 200 feet long and 12 feet high, showing a very uniform clay of gneissic texture, and bands of deep red and yellow. This material is very gritty, smooth, and sticky. Two samples were collected, one of these (Lab. No. 2041) representing the upper six feet, and the other (Lab. No. 2046) representing the bottom six feet. A comparison of the two is interesting, as it indicates how the upper and lower portions of a deposit may differ, and, consequently, in order to get an average sample, it should not be taken from too shallow a depth.

Sample No. 2041 is a red, fairly smooth, plastic clay, which absorbs a large amount of water in mixing, namely, 45 per cent, and has a high air shrinkage of 10 per cent. It burns to a red body of high absorption, but good ring, even at Cone 010, and is even steel hard at this cone. At Cone 010 the fire shrinkage and absorption were 0 and 26.7 per cent, respectively, while at Cone 05 they were 3 and 25.4 per cent. The material could be used for brick manufacture, but the high air shrinkage and high absorption are not altogether desirable. These troubles might be overcome by mixing with a material like No. 2048 (p. 43).

No. 2046 shows an interesting contrast with the preceding one (No. 2041). Its air shrinkage is about the same, but the fire shrinkage is higher and absorption lower, so that it forms a good material to mix with the upper six feet of the section.

As to its qualities, the clay is smooth, fairly plastic, requires 42 per cent of water for mixing, and has an average air shrinkage of 10.3 per cent. It burns to a good red color and has a good ring, becoming steel hard at Cone 05. At Cone 010 the fire shrinkage was 2.7 per cent, and absorption 14.4 per cent. At Cone 05 the fire shrinkage was 3.7 per cent, and absorption 11.9 per cent.

The material is a good brick clay.

HALIFAX COUNTY.

Virgilina.—The testing of this clay (Lab. No. 2058) was in the nature of an experiment, as there was some doubt as to whether it would work at

all. The pyroclastic rocks exposed in the railway cut just west of the station are only partially altered, so that no bed of true residual clay is present. But the altered rock is soft and easily ground up.

It gave a mass of very fair plasticity that required 27 per cent of water for tempering, and had an air shrinkage of 1.9 per cent. The tensile strength was low, not exceeding 15 pounds per square inch.

The soft-mud bricklets gave the following results:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	24.2
05	0.0	23.2
03	1.6	23.2
1	1.6	21.5

The absorption is high, and the product is not very good unless burned to Cone 03. The material could be used, but the addition of a little more plastic clay would greatly improve it.

SUMMARY OF TESTS OF PRE-CAMBRIAN VOLCANIC CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2062	Simplicity	41.0	Fair	9.2	.....	3.0	26.8	2.7	26.0	.....	.....	.....	.....
2048	Virso	23.0	Good	7.4	.....	0.3	12.0	1.0	9.0	.....	.....	.....	.....
2041	Virso	45.0	Good	10.0	.....	0.0	26.7	3.0	25.4	.....	.....	.....	.....
2046	Virso	42.0	Good	10.3	.....	2.7	14.4	3.7	11.9	.....	.....	.....	.....
2058	Virgilina	27.4	Fair	1.9	Not over 15.0	0.0	24.2	0.0	23.2	1.6	23.2	1.6	21.5

Comments on the Table.

The clays derived from the pre-Cambrian volcanic rocks are better than those derived from the Catoctin schist (altered basalt), and there is no reason why, so far as their properties are concerned, they should not be used in the manufacture of common brick.

PRE-CAMBRIAN GRANITE AND GRANITE-GNEISS CLAYS.

The rocks of this subdivision of the pre-Cambrian underlie two belts in the Piedmont area, and extend all the way across the State in a northeast-southwest direction.

The first or eastern belt is narrow at its upper end but widens rapidly southward, attaining its greatest width on the North Carolina boundary. Beginning at the north end and going south we find that it includes part or all of the following counties: Fairfax, Prince William, Stafford, Spottsylvania, Louisa, Caroline, Hanover, Goochland, Cumberland, Chesterfield, Amelia, Nottoway, Dinwiddie, Lunenburg, Mecklenburg, Brunswick, and Greeneville. This belt is traversed by a number of lines of railway.

The second or western belt passes through Loudoun, Fauquier, Rappahannock, Culpeper, Madison, Greene, Albemarle, Nelson, Amherst, Bedford, Floyd, and Carroll. The Southern Railway skirts the southeastern edge along its middle third. It is also crossed by railroads between Leesburg and Bluemont; Manassas and Front Royal; Charlottesville and Basic; Lynchburg and Roanoke; and Rocky Mount and Roanoke. On the whole, however, this belt is not as widely accessible by lines of railway as the eastern one.

Since then the pre-Cambrian granite and granite-gneiss group covers such a large portion of the Piedmont region in Virginia, it deserves careful consideration as a possible source of clay suitable for the manufacture of clay products. Samples for testing were, therefore, collected at a number of different points, which are referred to below.

PRE-CAMBRIAN GRANITE CLAYS.

SPOTTSYLVANIA COUNTY.

Fredericksburg.—No brickyards are in operation at Fredericksburg. The local granite is covered by residual clay, but the exposures do not show an abundance of the material. Two samples were taken from the clay overlying the granite in the quarries west of Fredericksburg, to obtain a clue to their properties. The one (Lab. No. 2032) was too sandy to work.

The other (Lab. No. 2033) was sufficiently plastic to mold, but dried to a rather tender bricklet. This burned red, but was not very hard and showed considerable mica. The absorption was also high, being 26.4 and 22.6 per cent at cones 010 and 05, respectively.

GOOCHLAND COUNTY.

Goochland.—The residual clay from the pre-Cambrian granite and gneiss is well represented by a large cut bank, a quarter of a mile north of Maidens Station on the Chesapeake and Ohio Railroad.

In the field the clay shows the foliated structure of the rock from which it was derived, but is easily dug.

The material (Lab. No. 2140) is a micaceous clay of fair plasticity, which required 46 per cent of water for tempering. The air shrinkage was 7.3 per cent, and the average tensile strength not over 20 pounds per square inch. The bricklets made from this clay burned to a good red color, with a fair ring at Cone 05, and a good ring at Cone 03. They became steel hard at Cone 1. The other fire tests on the soft-mud bricklets are as below.

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.3	28.4
05	2.0	26.3
03	2.3	26.0
1	5.0	22.6

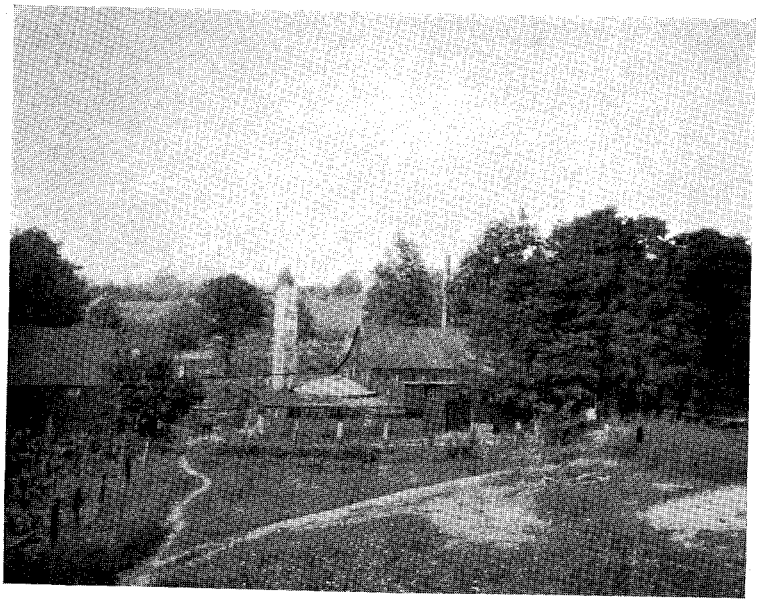
This clay could be used for common brick, but its absorption is a little high.

CUMBERLAND COUNTY.

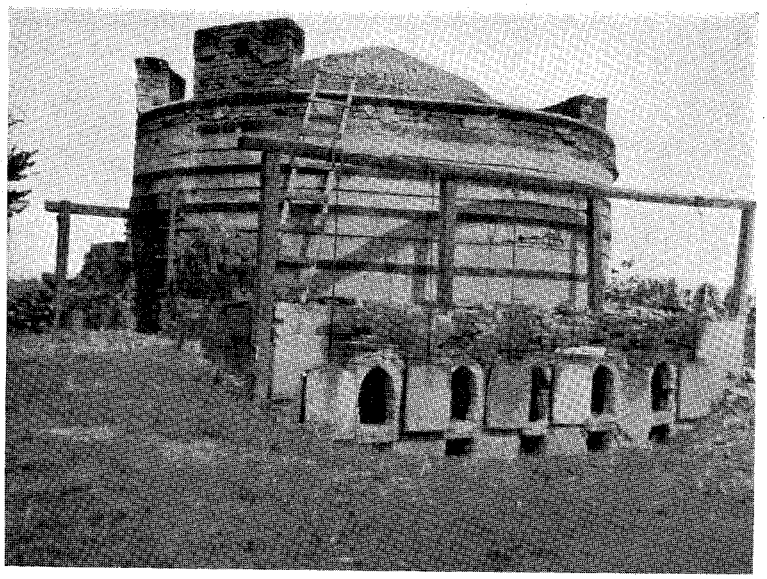
Cumberland Courthouse.—On the road to Cumberland, from Farmville, there is much clay exposed in cuts as far as George (3 miles from Farmville). It is all quite sticky, and seems to be derived from a gneissic or schistose phase of the granite.

The following sample (Lab. No. 2044) is fairly typical of these exposures. It is red, sandy, not very plastic, micaceous clay, requiring 33 per cent of water for mixing, and having 7.8 per cent air shrinkage. The fire shrinkage at both cones 010 and 05 was .4 per cent, and the absorption was 24 per cent in each case. The bricklets were red and had a fair ring at the cones mentioned. The clay could be used for common brick, even though it does not burn very dense.

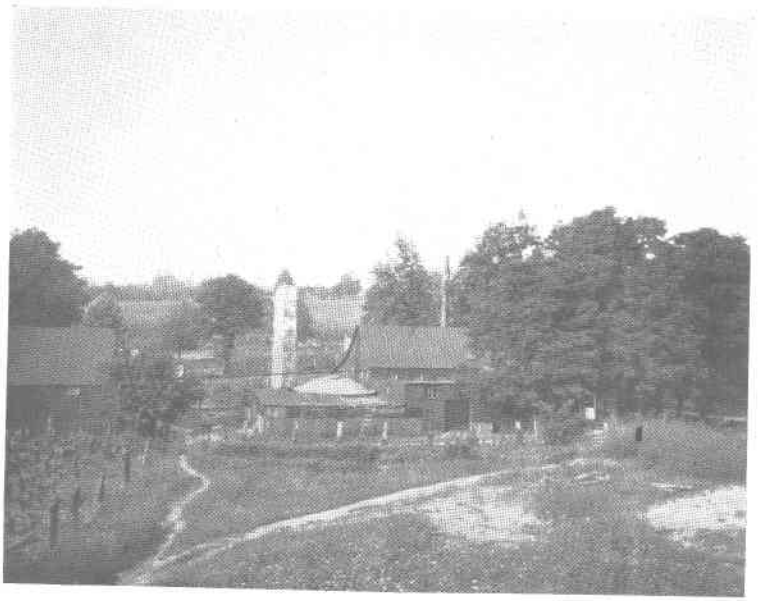
There is also a fair amount of red clay around Cumberland, but it varies somewhat in its character, depending on the nature of the bedrock.



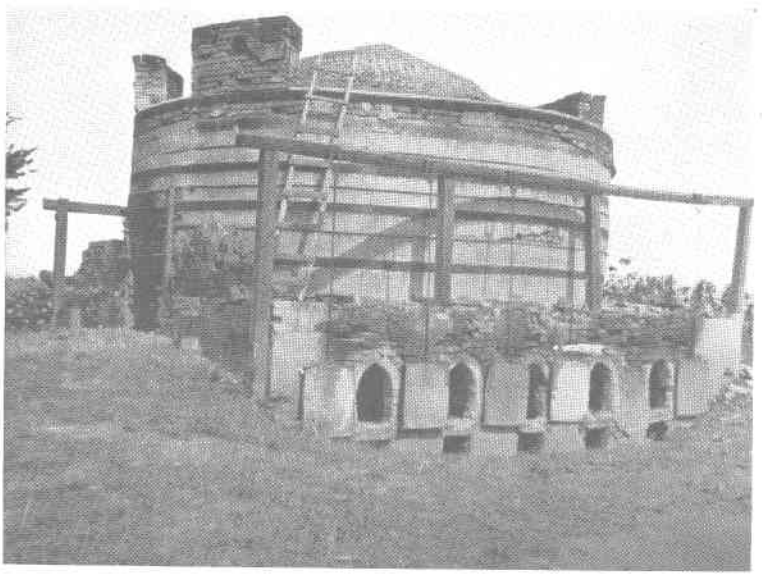
(A) Pipe works at Pamplin.



(B) Kiln at Stevensburg brick plant.



(A) Pipe works at Pamplin.



(B) Kiln at Stevensburg brick plant.

The following tests made on a sample from a large bank near town are perhaps a little better than the average of this district. Like the preceding, this material (Lab. No. 2051) is also a red, sandy, micaceous clay of not very high plasticity. It took 34 per cent of water for mixing, had an air shrinkage of 6.1 per cent, and an average tensile strength of 85 pounds per square inch. The clay burns to a good bricklet of red color and having a good ring, even though the absorption is not very low.

Soft-mud bricklets yielded the following shrinkage and absorption tests:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.0	24.7
05	2.0	23.7
03	2.7	20.5
1	3.7	18.4

This material could be used for brick manufacture.

POWHATAN COUNTY.

Ballsville.—The residual clay from the pre-Cambrian granite is exposed in a 4-foot depth of cut, just east of the station on the Tidewater and Western Railroad.

The clay (Lab. No. 2209) is red, somewhat coarse-grained due to mica and sand, but it has good plasticity. It required 28 per cent of water to temper it, and the air shrinkage was 4.7 per cent. At Cone 010 the fire shrinkage was .7 per cent, and the absorption 24.8 per cent, while at Cone 05 there was little difference in either the shrinkage or the absorption.

The bricklets though of good color are not sufficiently hard even at Cone 05 to make a first-class product.

Powhatan.—A fair amount of clay is to be seen in the cuts of the Tidewater and Western Railroad in Powhatan County, and, while the sections are not very deep, the decay of the rock seems to be fairly thorough. The soil is red and sticky.

One sample taken from a cut just west of Powhatan Station may be taken as fairly typical of many of the exposures. The material (Lab. No. 2210) is a red sandy clay of slight plasticity, working up with 27 per cent of water, and having 4.2 per cent air shrinkage. The clay when burned to the temperature usually reached in common-brick kilns makes a nice-looking bricklet, but not a very hard nor a very dense one. It could be used for small buildings. At Cone 010 the fire shrinkage and absorption were 1 and 26.5 per cent, respectively, while at Cone 05 they were 1.4 and 27.0 per cent.

Moseleys.—One-half mile east of Moseleys are several fair-sized cuts on the line of the Southern Railway. There are no rock exposures, and there is some doubt as to whether the material is derived from the pre-Cambrian granite or Triassic formations. Much of the clay is yellowish-brown, with streaks of very plastic gray clay running through it. The material is red-burning and capable of making a good common brick.

Michaux.—Here again the residual clay from the pre-Cambrian granite is obtainable, and there is at least one good section, 200 by 10 feet, exposed. The material (Lab. No. 2200) is a red sandy clay of fair plasticity, having 5 per cent air shrinkage when worked up with 32 per cent of water. It burned to a red bricklet of good appearance, but not great hardness. The fire shrinkage at both cones 010 and 05 was zero, and the absorption about 26 per cent.

Jefferson.—This is the only locality in Virginia where local clay is used exclusively for smoking-pipe manufacture. The deposit, which is probably of residual nature, lies near a stream about 1¼ miles east of Jefferson. The clay is yellow and plastic. It is strained through cloth into wooden tanks and allowed to settle. After drawing off the excess of water, it is mixed in a blunger, and tempered in a vertical pugmill. As the bar of clay issues from the mill, pieces are broken off and formed into pipes in the press. The latter are burned in a small kiln.

The two following sets of tests indicate the character of No. 2139 the crude clay, and No. 2077 the strained clay:

The crude clay is smooth and highly plastic. With 31 per cent of water it molds up well, and has 7.5 per cent air shrinkage. In burning it yielded a nice red body, with good ring and moderate absorption. As compared with the other residual clays from the pre-Cambrian granites and gneisses, it is much finer-grained, more plastic, and denser burning. At Cone 010 the fire shrinkage was 1 per cent, and absorption 19.1 per cent. At Cone 05 these figures were 2.7 and 16 per cent, respectively.

The washed clay is very smooth and plastic, and worked up with 40 per cent, the bricklets made from this showing 7.9 per cent air shrinkage. The clay burns to a nice red, smooth body, with a good ring, and steel hard at Cone 05. At Cone 010 the fire shrinkage was 0 per cent, and absorption 27 per cent, while at Cone 05 they were 3 and 20.5 per cent, respectively.

Clayville.—A brick and tile works was in operation at this locality from 1892 to 1907, and produced common, ornamental, and fire brick. The clay

supply, which was not properly prospected beforehand, gave out, and for several years clay was shipped in from other points.

NOTTOWAY COUNTY.

Nottoway.—The residual clay around Nottoway is all red, fairly plastic, and contains a moderate number of feldspar-quartz stringers, which would have to be crushed before running the clay through a brick machine.

The following sample taken from a large road cut illustrates the character of the material around Nottoway. The clay (Lab. No. 2204) is red, somewhat coarse-grained, micaceous, and of good plasticity, working up with 36 per cent of water to a mass whose air shrinkage was 7.2 per cent, and average tensile strength 75 pounds per square inch.

It makes a fair common brick, and one which is not as absorbent as many of the others from this region. It could probably be worked in a stiff-mud machine, although we did not have a sufficiently large sample to try it.

The fire tests on the bricklets were as follows:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.3	23.0
05	1.3	21.9
03	4.0	18.3
1	4.3	17.1

Burkeville.—One-third mile east of the Norfolk and Western Railway station is a cut a third of a mile long and 15 feet deep. It consists mostly of a yellow to brown decomposed granite, with streaks and patches of red.

At the eastern end of the cut is a disintegrated white granite with pegmatite stringers, while at the western end of the cut is another patch of the same material (Lab. No. 2207). This residual clay is very sandy, of low plasticity, and air shrinkage of 1 per cent. It burns buff, and requires too high firing to make it of use for commercial brick. It might do for the boiler-setting brick.

Just east of the station on the Norfolk and Western Railway there is a cut about 175 feet long and 8 feet high, consisting of yellowish-brown clay with light streaks. The material (Lab. No. 2049) is of good plasticity, and works up with 27 per cent water. It had an air shrinkage of 5.8 per cent, and average tensile strength of 81 pounds per square inch.

The soft-mud bricklets burned to a buff body, but one that flashed rather easily in the firing, and if fired to Cone 03 had a good ring, although

a product was obtained at Cone 05 that would probably be salable. On firing the soft-mud bricklets showed the following additional properties:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.0	20.4
05	.1	20.4
03	.2	15.8
1	1.7	16.4

This clay should make a good common brick by the soft-mud process. A sample was also put through the stiff-mud machine, and flowed through the brick die without any difficulty. Another sample was molded into dry press, but did not give a sound bricklet under Cone 1. This clay is unlike most of the other residuals from this formation in its color-burning qualities, for it yields a buff product.

At High Bridge on the Norfolk and Western Railway there is another cut containing decomposed pegmatite, in fact considerable clay is exposed in the cuts here.

Blackstone.—There are no exposures of clay on the road west of Blackstone, but in a cut on the Norfolk and Western Railway, just east of the freight depot, a good section in the residual clay is to be seen. The deposit is at least 12 feet thick, and seems to be quite uniform in character.

The clay (Lab. No. 2011) is slightly sandy, but of good plasticity. With 29 per cent of water it gave a nice moldable mass. The air shrinkage was 7.5 per cent, and the average tensile strength 77 pounds per square inch. It burns red, and gives a good sound product at Cone 03, and even a fair one at Cone 05.

The firing tests of the soft-mud bricklets were:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	20.8
05	1.0	19.0
03	1.4	17.0
1	2.5	15.34

A second lot of the clay was tested out in the stiff-mud machine. It worked finely in the brick die, and also fairly well in the hollow-brick die. The clay would make a good red brick, and could probably be used also for hollow brick.

One-half mile west of Blackstone is the brickyard of Adams and Cannon, not now in operation. The clay is fairly plastic, red, and full of quartz stringers. The bricks that were made from it are rather soft.

The air shrinkage of this clay (Lab. No. 2208) is 3.7 per cent, rather characteristic of a sandy clay. While the bricklets made from this clay burned to a good red color, they would have to be fired above Cone 05 to make a salable product. The fire shrinkage up to this cone is zero, and the absorption 23 per cent.

If a more plastic clay were added, it would give a better product.

DINWIDDIE COUNTY.

Dinwiddie.—For at least a quarter of a mile west of the station there are several good cuts, some of them 10 feet deep. The material in all is residual clay from a coarse-grained granite, and that described below (Lab. No. 2061), shows the character of the clay.

It is micaceous gritty clay of good plasticity. Water required for mixing, 31 per cent; air shrinkage, 5.3 per cent; average tensile strength, 68 pounds per square inch. The material burns to a reddish-buff bricklet, and while the working qualities are good, and the absorption not excessive, it has to be well burned to give a good ringing brick.

The soft-mud bricklets gave the following results:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.4	22.2
05	.7	21.6
03	3.0	18.0
1	3.0	19.6

A sample of the clay worked in the stiff-mud machine without any difficulty, and gave a fair brick.

LUNENBURG COUNTY.

Kenbridge.—The bedrock around Kenbridge appears to be a complex of chiefly gneisses, schists, and granites, but exposures of the fresh rock are rare. The clays are all shades of red, yellow, gray, greenish-gray, and white. They range from plastic to lean and sandy.

A brickyard was formerly located on the site of the present Kenbridge roller mill, but the bricks to be seen in some of the buildings did not appear to be very uniform.

A sample, representing average material, was taken from a cut 300 feet in length just east of the station. The material (Lab. No. 2010) represents a red sandy clay of good plasticity. It worked up with 33 per cent of water, the bricklets made from this having 7.5 per cent air shrinkage, and

125 pounds per square inch tensile strength. The clay burns red, and gives a very fair brick even at Cone 010. The soft-mud bricklets also gave the following additional data after firing:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.7	22.5
05	.7	20.0
03	3.0	18.7
1	3.7	16.79

Another sample was run through the stiff-mud machine. It flowed readily through the brick die, but the whitish lumps in the clay did not pug up very easily. This clay seems well adapted for making building brick. If burned hard enough it might be possible to make a dry-press brick from the material.

Victoria.—A mile or so east of the railroad station is a long cut of whitish residual clay. No sample of it is available for testing, but it may be buff-burning.

Meherrin.—A fine cut of residual clay, 18 feet deep and about half a mile long, is to be seen on the Virginian Railway west of Meherrin Station. The clay is red, fairly sticky, and not always very deep, but the rock below it is badly rotted.

The material (Lab. No. 2089), which is noticeably micaceous, worked up with 43 per cent of water to a mass of good plasticity, with 9.1 per cent air shrinkage, and 86 pounds per square inch tensile strength. The bricklets burned at Cone 010 had a good red color and fair ring, and the same held true at Cone 05, but at Cone 03 there was an appreciable increase in the fire shrinkage, at which cone the bricklets also became steel hard.

Other fire tests on the wet-molded bricklets were:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	28.9
05	1.0	27.9
03	3.6	16.2

The absorption is somewhat high, but otherwise the product is good. The clay was also found to work in the stiff-mud machine.

At one point in the cut above mentioned, about 250 yards from the railway station, the clay is light-colored, plastic, and badly stained with iron and some black-staining matter.

In a small sample the clay (Lab. No. 2042) looks as if it might have been derived from a pegmatite, because of its cream color. It is smooth and of good plasticity. After mixing with 26 per cent of water it had 8.3 per cent air shrinkage. The clay burned to a nice red bricklet, with good ring at Cone 010, and the absorption was lower than is usually found in these residuals. At Cone 010 the fire shrinkage was .7 per cent, and absorption 14.9 per cent, while at Cone 05 they were 1.7 per cent, and 12.7 per cent, respectively. The clay would probably work in a stiff-mud machine. It is a good red brick clay, and might also serve for making hollow blocks.

MECKLENBURG COUNTY.

Lacrosse.—There are but few cuts around Lacrosse, hence it is difficult to estimate the amount of clay in this vicinity. Where any clay is exposed it is mostly red, but covered with a surface soil of yellow or gray color.

The following sample (Lab. No. 2070) is fairly typical of the residual clay in this vicinity, and was collected from a road cut near the high school. The tests showed it to be a red clay of good plasticity. Its air shrinkage after mixing with 46 per cent of water was 8.8 per cent, which is a little high, and the average tensile strength 86 pounds per square inch. It burns to a red color, and has a fair ring even at 010.

The other tests on the soft-mud bricklets were:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	2.4	27.2
05	4.0	24.2
03	8.0	13.9
1	8.6	13.5

The material should make a good common brick, burning hard at a low cone. It does not work very well dry press, but might run satisfactorily through a stiff-mud die.

Clarksville.—Immediately around Clarksville, especially on the south, there is much red clay exposed in gullies and shallow road cuts, the bedrock in places being schistose, in others gneissic, or even in some places massive in structure.

As a type of the clay derived probably from schist, reference may be made to the old road cut, a third of a mile south of town, and south of the Petersburg road, as well as 100 yards north of the bridge. The material (Lab. No. 2066) is a smooth red clay of good plasticity. The trial bricklets had 6.2 per cent air shrinkage when mixed with 31 per cent water.

They burned to a red color, and good ring even at Cone 010, and became steel hard at Cone 05. The fire shrinkage and absorption at Cone 010 were 2.3 and 25.4 per cent, respectively, while at Cone 05 they were 3 and 22.4 per cent, respectively. From these few preliminary tests the material gives promise of making good common brick.

A deposit, derived from more gneissic rock, is to be seen in a cut on the Petersburg road, 150 feet south of the bridge, and about half a mile south of town, the cut being 100 by 7 feet, and the clay extending nearly to the bottom of the cut.

This clay (Lab. No. 2065) is red like the preceding, but quite sandy and not as plastic, although there was no trouble in molding it. After mixing with 27 per cent of water it showed an air shrinkage of 6.3 per cent. The clay burns red, and has a fair ring even at Cone 010, although of high absorption. At Cone 010 the fire shrinkage was zero, and absorption 33.4 per cent, while at Cone 05 the fire shrinkage was 1 per cent, and absorption 21.8 per cent. The clay could be used for brickmaking.

Just at the edge of town, on the same road, is a bank 175 by 10 feet composed of clay derived from a coarse-grained gneiss or granite, and so quartzose as to be very deceptive as to its plasticity. The material (Lab. No. 2071) is a yellowish-brown, very sandy clay, of moderate plasticity. The bricklets made from the clay when mixed with 30 per cent water had an air shrinkage of 5 per cent, and were not very hard. They burned to a red brick, but the product was not very hard even though the absorption was moderate. The fire shrinkage and absorption at Cone 010 were zero and 19.5 per cent, respectively, and at Cone 05 they were practically the same.

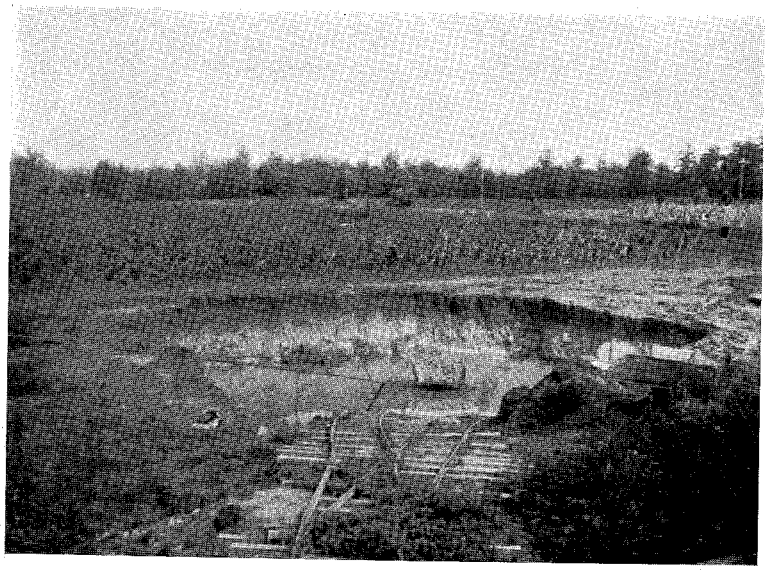
Judging from this sample, the material is not a very good brick clay.

To the east of Clarksville on the National Highway is a red plastic clay, occurring in considerable quantity in shallow cuts, but with no exposure of bedrock. Here, again, we have a red smooth clay (Lab. No. 2031) of good plasticity. With 29 per cent of water it worked up to a mass having 7.4 per cent air shrinkage, and 68 pounds per square inch tensile strength.

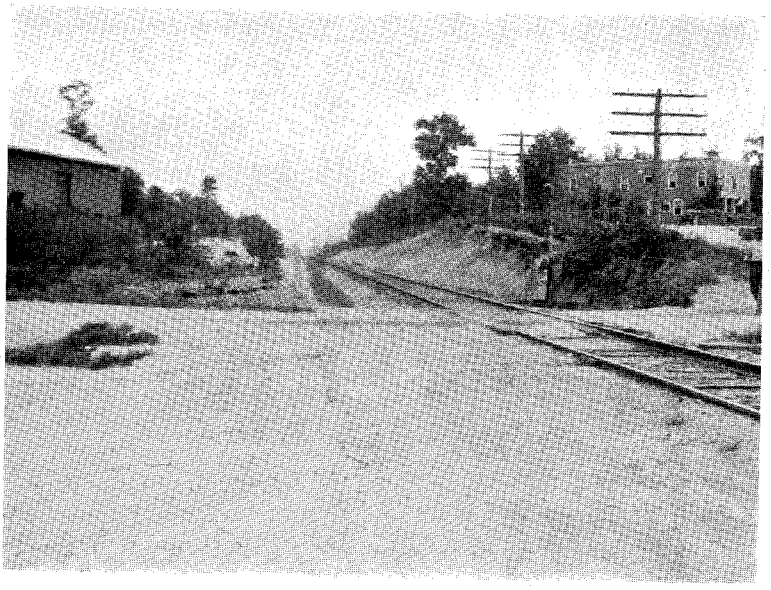
The soft-mud bricklets burned red and had a good ring even at Cone 010. They became steel hard at Cone 05, but if burned to Cone 1, while hard and sound, the color became too dark.

Other tests on these soft-mud bricklets are as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.3	20.1
05	1.7	12.4
1	4.3	14.4



(A) Residual clay near Lawrenceville.



(B) Residual clay near Alberta.

(A) Residual clay near Lawrenceville.

(B) Residual clay near Alberta.

The clay also worked fairly well in the brick die of the stiff-mud machine, but showed a tendency to tear in the hollow-brick die. This may possibly have been the fault of the die. There seems no reason why this material should not be used to make a good grade of brick.

Boydton.—Residual clay from granite is well exposed on the National Highway, 1 mile west of Boydton, the bank being about 250 by 9 feet. This represents a type which is plentiful in this area, being noticeable in cuts all the way from Boydton to Clarksville.

A sample was tested from the large bank near Boydton, with the following results: The material (Lab. No. 2088) is a red smooth clay of good plasticity. It required 42 per cent of water to work it up, and the bricklets made from the clay had an air shrinkage of 7.9 per cent, and an average tensile strength of 48 pounds per square inch. The clay burned to a good red color, with a fair ring at Cone 010, and an excellent ring at Cone 03, at which temperature they were steel hard.

The fire shrinkage and absorption were as follows:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.4	32.
05	.4	31.8
03	3.3	22.2
1	4.0	23.6

The clay would probably work in a stiff-mud machine. There seems no obstacle to using this clay for the manufacture of good common brick. It is not to be recommended for a dry-press product.

BRUNSWICK COUNTY.

Alberta.—Several good cuts of residual clay occur along both the Seaboard Air-Line and the Virginian railways near Alberta. The best one is just east of Alberta on the Seaboard Air-Line Railway. Here in a cut about 300 by 10 feet is a mass of light gray, yellow, and red clay, with many small stringers of decomposed pegmatite.

This bank was sampled to include all except the top foot, and gave very satisfactory results on testing. The clay (Lab. No. 2028) is somewhat gritty and of moderate plasticity. Its air shrinkage when mixed with 32 per cent of water was 7.1 per cent, and the average tensile strength 70 pounds per square inch. It burns to a reddish-brown color, and gives a good brick at Cone 05, but is a little too soft at Cone 010. The absorption is moderate. The soft-mud bricklets behaved as follows:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.0	21.6
05	1.3	21.1
03	4.7	14.8
1	4.6	14.1

Although the clay is sandy, it flowed through the brick die of the stiff-mud machine without difficulty. The tests indicate the probability of making brick from this clay by either the soft-mud or stiff-mud process. It did not work well dry press.

Cochran.—Just west of the railroad station is a cut, 250 to 300 feet long and 15 feet deep, showing a fine exposure of red plastic clay to its full depth. No test was made of it, but the material would probably work for brick.

Lawrenceville.—In the vicinity of Lawrenceville there are a moderate number of cuts, showing red residual clay. On the northern edge of town, along the Cochran road, is a bank about 150 by 10 feet, showing red clay, rather typical of this vicinity.

The clay (Lab. No. 2060), although containing considerable finely divided mica, had fair plasticity. With 40 per cent water it gave a workable mass whose air shrinkage was 5.8 per cent, but whose average tensile strength was low, not exceeding 15 pounds per square inch. To give a good product it should be burned to at least Cone 05 and preferably Cone 03. The color after burning is red, and the bricklets at Cone 03 were steel hard.

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.0	31.2
05	2.3	30.3
03	4.0	22.0
1	4.0	22.6

It worked well in the brick die of the stiff-mud machine, and even flowed pretty well through the hollow-brick die.

There is no reason why this clay could not be used to advantage in the manufacture of good common brick, and it might even serve for making hollow brick.

Brodnax.—Several good cuts of red clay are to be found along the railroad between Brodnax and Lawrenceville.

ALBEMARLE COUNTY.

Crozet.—The country both north and south of Crozet, for a reasonable distance from the railroad, was looked over in search for good clay. A number of exposures were found, but, as will be seen from the tests noted below, the deposits were not of equal value. Just north of Brownsville, which is south of Crozet, a yellowish-brown clay, with scattered rock fragments, is to be seen.

This material (Lab. No. 2078) is of fair plasticity, and worked up with 33 per cent of water to a mass whose air shrinkage was 5.4 per cent, and average tensile strength 59 pounds per square inch. The clay burns red, is steel hard at Cone 03, but has a fair ring at Cone 010.

Further tests are as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.0	23.7
05	.7	21.9
03	2.7	19.3
1	3.0	18.4

This clay should make a good common brick by the soft-mud process, and could probably be worked also in the stiff-mud machine.

A little farther north residual clay outcrops again (Lab. No. 2076). This is a brown, plastic, smooth clay, which burns red, and has a low air shrinkage, but does not give a sufficiently hard brick at Cone 010. It should be burned to Cone 05 for good results.

Along the road up to half a mile north of Crozet Station there are several cuts showing very consistent and homogeneous clay, and one sample (Lab. No. 2055) taken from a point a quarter of a mile north of the railroad is quite typical. This red-brown clay has good plasticity. With 31 per cent of water it developed a workable body for soft-mud molding. The air shrinkage is 5.2 per cent, but the average tensile strength is not over 15 pounds per square inch. It burns to a red bricklet, steel hard at Cone 03, but not sound enough unless fired to Cone 05.

Further tests on the soft-mud bricklets are tabulated below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	.3	25.1
05	2.7	23.0
03	4.7	16.8
1	4.7	17.3

The clay will flow through the brick die of the stiff-mud machine, but care had to be used to prevent the bar from tearing as it issued from the die. It did not work dry press. This material can be used for making common brick if properly fired. It would work in a soft-mud machine, and might work in a stiff-mud one.

NELSON COUNTY.

Roseland.[a]—This district contains: (1) Red residual clay derived from gabbro, quartz monzonite, and the hornblendic phase of the rutile-bearing syenite, and (2) kaolin or white residual clay derived from the purer feldspathic phase of the syenite. The latter is discussed under the kaolins. The other group is referred to here.

Near the mine of the American Rutile Company there is considerable residual clay derived from the quartz-bearing syenite. The material (Lab. No. 2185) is red-brown, smooth, and contains scattered grains of blue quartz, which does not break down on weathering. With 35 per cent water it works up to a mass of good plasticity, and has 8.4 per cent air shrinkage. The clay burns red, has a good ring at Cone 010, and is steel hard at Cone 05. At Cone 010 the fire shrinkage and absorption were 2.4 and 26.9 per cent, respectively, while at Cone 05 they were practically the same.

There is no reason why this clay should not be used for making common brick, if molded in a soft-mud machine, and, while it would probably flow through the die of a stiff-mud machine, the many small quartz fragments would interfere with the cutting wires.

In this same district there is a variable amount of residual clay derived from the quartz-monzonite, but there are few good sections in it and most of these show a somewhat sandy clay. Near Colleen, about 1,000 yards south of it, on the Roseland-Arrington Highway, there is a deposit of clay which is evidently washed from the quartz monzonite residuals. Although sandy, the material (Lab. No. 2170) is plastic and of low air shrinkage. It burns buff at both cones 010 and 05, with about 14 per cent absorption.

AMHERST COUNTY.

Amherst.—The region around Amherst is underlain by quartz-monzonite gneiss, which varies in places both structurally and in mineral composition. Hence with variation in the character of the underlying

[a] For a detailed discussion of the geology of this district, *see* Watson and Taber, Bull. III-A, Va. Geol. Survey, 1913.

rock there will be more or less variation in character of the residual clay derived from it, aside from differences due to the stage of decay of the material.

The clays around Amherst seem to be rather irregular in depth, and the more schistose phase of the quartz-monzonite seems to weather more readily to clay than the coarser-grained, normal rock. Several cases may be quoted to show the character of the clays obtainable around Amherst.

On Buffalo Hill, about 2 miles north of Amherst, there occurs rather an extensive exposure of tough clay (Lab. No. 2093), which appears to be of promising character. It is a smooth red clay of good plasticity. If mixed up with 31 per cent water the bricklets molded therefrom had an air shrinkage of 6.9 per cent, and an average tensile strength of 67 pounds per square inch.

These wet-molded bricklets burn to a good red color up to Cone 05, but to a considerably darker color above this. They were steel hard at Cone 1, and had a fair ring at Cone 05, but showed a little tendency to develop surface cracks. The other soft-mud tests are as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	23.1
05	.4	18.3
1	1.4	15.7

Molded in the stiff-mud machine, the clay worked well through the die if not too wet. It is probable that red brick could be made from this clay by either the soft-mud or stiff-mud process.

On the south side of Buffalo River, along the short-cut road connecting the two curves of the toll road, is a long cut of very sandy material, which is only partly decomposed (Lab. No. 2057). It is so micaceous and of such low plasticity as to be unfit for brick manufacture.

About 1 mile south of Amherst the surface clay is redder, more plastic, and more promising than the preceding. This material (Lab. No. 2074) is smooth and plastic. With 35 per cent water it gave a mass that was easily molded, and had 8.1 per cent air shrinkage.

The bricklets burned red, had a fair ring at Cone 010, and an excellent ring at Cone 05. At Cone 010 the fire shrinkage and absorption were, respectively, .6 and 30 per cent. At Cone 05 they were 2 and 28.2 per cent.

These few preliminary tests indicate that the material could serve at least as a local source of supply for the manufacture of common brick.

No bricks are made from the clays around Amherst, and, owing to the hilly nature of the country, a brick plant if started should be located fairly close to the railroad.

The buildings of Sweet Briar College are said to have been made from local clays.

BEDFORD COUNTY.

Bedford City.—Residual clays from granite occur throughout this district, but there are few good exposures in wagon or railroad cuts. One of the best is on the road to Thaxton, and just west of Bedford City, where the ferruginous clay shows in a cut about 6 feet deep.

The material (Lab. No. 2098) is a fairly plastic red clay of slightly micaceous character. Worked up with 34 per cent water it had 7.8 per cent air shrinkage. At Cone 010 the fire shrinkage and absorption were, respectively, .4 and 26.6 per cent, while at Cone 05 they were 1.4 and 23.5 per cent. The bricklets had a good ring and red color at Cone 010. From these tests we feel sure the material would work for common brick.

A mile farther west on the same road is another and larger bank, probably 15 feet high, and lying between the highway and the railroad. This is also a good red-burning clay.

Again just west of the railroad station on the north side of the track, residual clays from granite-gneiss are exposed in several cuts, but only the upper portion is decayed enough to yield a clay worth working, the lower part (Lab. No. 2096) being so sandy as to yield a soft porous brick.

Between Bedford City and Lynchburg there are a number of cuts, some like those at Lowry and Forest appearing to contain considerable clay.

SUMMARY OF TESTS OF PRE-CAMBRIAN GRANITE CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2032	Fredericksburg	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2033	Fredericksburg	.....	.....	4.9	.....	0.0	26.4	3.6	22.6	.....	.....	.....	.....
2140	Goochland	46.0	Only Fair	7.3	Not over 20.0	1.3	28.4	2.0	26.3	2.3	26.0	5.0	22.6
2044	Cumberland	33.0	.....	7.8	.....	0.4	24.6	0.4	24.3	.....	.....	.....	.....
2051	Cumberland	34.0	Slight	6.1	85.0	1.0	24.7	2.0	23.9	2.7	20.5	3.7	18.4
2209	Ballsville	28.0	Good	4.7	.....	0.7	24.8	0.6	25.3	.....	.....	.....	.....
2210	Powhatan	27.0	Slight	4.2	.....	1.0	26.5	1.4	27.0	.....	.....	.....	.....
2200	Michaux	32.0	Fair	5.0	.....	0.6	26.6	0.0	27.6	.....	.....	.....	.....
2139	Jefferson	31.0	High	7.5	.....	1.0	19.1	2.7	16.0	.....	.....	.....	.....
2077	Jefferson	40.0	.....	7.9	.....	0.0	27.0	3.0	20.5	.....	.....	.....	.....
2204	Nottoway	36.0	.....	7.2	75.0	1.3	23.0	1.3	21.9	4.0	18.3	4.3	17.2
2207	Burkeville	15.0	Very Low	1.0	.....	0.0	.....	1.0	15.7	.....	.....	.....	.....
2049	Burkeville	27.0	Good	5.8	81.0	0.0	20.4	1.0	20.4	2.0	15.8	2.7	16.4
2011	Blackstone	29.0	Good	7.5	78.0	0.0	20.8	1.0	19.0	1.4	17.0	2.5	15.3
2208	Blackstone	22.0	Low	3.7	.....	0.0	23.0	0.0	23.1	.....	.....	.....	.....
2061	Dinwiddie	31.0	Good	5.3	68.0	0.4	22.2	0.7	21.6	3.0	18.0	3.0	19.6
2010	Kenbridge	33.0	Good	7.5	126.0	0.7	22.5	0.7	20.0	3.0	18.7	3.7	16.8
2089	Meherrin	44.0	Good	9.1	86.0	0.0	28.9	1.0	27.9	3.6	16.2	.....	.....

SUMMARY OF TESTS OF PRE-CAMBRIAN GRANITE CLAYS—Continued.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption.	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2042	Meherrin	26.0	.....	8.3	.....	0.7	14.9	1.7	12.7	.....	.....	.....	.....
2070	Lacrosse	46.0	Good	8.8	86.0	2.4	27.2	4.0	24.2	8.0	13.9	8.6	13.5
2066	Clarksville	31.0	.....	6.2	.....	2.3	25.4	3.0	22.4	.....	.....	.....	.....
2065	Clarksville	27.0	.....	6.3	.....	0.0	33.4	1.0	21.8	.....	.....	.....	.....
2071	Clarksville	30.0	.....	5.0	.....	0.0	18.6	0.6	19.5	.....	.....	.....	.....
2031	Clarksville	29.0	Good	7.4	69.0	1.3	20.1	1.7	18.4	.....	.....	4.3	14.4
2088	Boydton	42.0	Good	7.9	48.0	0.4	32.0	0.4	31.8	3.3	22.2	4.0	23.6
2028	Alberta	32.0	Moderate	7.1	70.0	0.0	21.6	1.3	21.1	4.7	14.8	4.6	14.1
2060	Lawrenceville	40.0	Fair	5.8	15.0	1.0	31.2	2.3	30.3	4.0	22.0	4.0	22.6
2078	Crozet	33.0	Fair	5.4	60.0	0.0	23.7	0.7	21.9	2.7	19.3	3.0	18.4
2076	Crozet	30.0	.....	4.6	.....	0.4	.....	.....	.....	.....	.....	.....	.....
2055	Crozet	31.0	Good	5.2	15.0	0.3	25.1	2.7	23.0	4.7	16.8	4.7	17.3
2185	Roseland	35.0	Good	8.4	.....	2.4	26.9	2.4	26.4	.....	.....	.....	.....
2170	Colleen	20.0	Fair	2.7	.....	0.0	14.4	.....	.....	.....	.....	.....	.....
2093	Amherst	31.0	Good	6.9	67.0	0.0	23.1	0.4	18.3	.....	.....	1.4	15.7
2057	Amherst	32.0	Low	3.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
2074	Amherst	35.0	.....	8.1	.....	0.6	30.0	2.0	28.2	.....	.....	.....	.....
2098	Bedford City	34.0	.....	7.8	.....	0.4	26.6	1.4	23.5	.....	.....	.....	.....
2096	Bedford City	28.0	Moderate	2.0	.....	.....	.....	.....	.....	.....	.....	.....	.....

(A) Residual clay near Louisa.

(B) Residual clay containing limonite near Pittsville.

(A) Residual clay near Louisa.

(B) Residual clay containing limonite near Pittsville.

Comments on the Table.

The residual clays derived from the pre-Cambrian granites and gneisses are mostly of good plasticity, so that they can be molded without difficulty, some of them working well in the stiff-mud machine. They also burn to a good color. Many of them could be used for the manufacture of common brick and some of them for hollow tile.

PRE-CAMBRIAN CRYSTALLINE SCHISTS AND GNEISS CLAYS.

There is one irregular but important belt or area of rocks of this subdivision of the pre-Cambrian.

It enters the State in Fairfax County, and crosses parts of Prince William, Culpeper, Stafford, Orange, Spottsylvania, Louisa, and Fluvanna counties. It then widens out in Buckingham, Appomattox, Prince Edward, Campbell, Charlotte, Halifax, and Pittsylvania counties. A broad triangular area including parts of Grayson, Carroll, Patrick, Floyd, Henry, and Franklin counties lies on the west.

Except for the last-mentioned triangular area, the formation is traversed by a number of lines of railway, and, next to the pre-Cambrian granite belt, is the most important from standpoint of size in the Piedmont province.

LOUISA COUNTY.

Louisa.—The residual clays around Louisa are mostly red burning, although there are some exceptions.

Thus about three-quarters of a mile due northeast of Trevilians there is a deposit of whitish clay near J. L. Latham's house. A pit about 50 feet square was opened some 22 years ago, and brick made from it. The clay, which seems to occur in some quantity, is very sericitic, and contains considerable quartz. There is some doubt as to whether it is derived from a pegmatite or from a schist containing stringers of pegmatite.

As tested out in the laboratory, the material (Lab. No. 2034) was cream-colored, contained much fine grit, and was low in plasticity. Air shrinkage 4.4 per cent. Two trial burns were made on it, one at Cone 010 and the other at Cone 05. The fire shrinkage in each case was low, and the absorption about 20 per cent. At neither of these cones was the bricklet very solid.

The material does not appear to contain much iron, and, while of no value for building brick, it might if burned harder serve for boiler-setting brick.

At another point, 1¾ miles due northeast of Trevilians, there is a bank of clay 70 feet long, which appears to be derived from the weathering of granite. Several other exposures of the same material are to be found near-by, so that it is probably rather abundant. The clay (Lab. No. 2082) is a dark brown, plastic, sandy material, requiring little water to mix (24 per cent) as compared with many others. The air shrinkage was 6.2 per cent. The clay burns to a nice red color, but must be fired above Cone 05 to give a good hard brick. At this cone the absorption is 18 per cent.

A third locality is well exposed about 1½ miles north of Louisa on the road to Ellisville. Here there is a bank about 200 feet long with a maximum depth of 8 feet. This material (Lab. No. 2087) is a red micaceous clay, containing scattered fragments of the bedrock. It has fair plasticity, and, when mixed up with 40 per cent of water, showed 7.4 per cent air shrinkage. The average tensile strength was 97 pounds per square inch. The clay burns red, and the bricklets had a fair ring even at Cone 010, although they did not become steel hard until Cone 03. At this cone also the color became appreciably darker.

Other tests on the soft-mud bricklets are given herewith:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	24.4
05	1.0	22.6
03	4.0	16.0
1	4.4	16.0

This clay would make a common brick, but might not work in a stiff-mud machine. At several places on the road leading north from Louisa there is clay exposed resembling sample No. 2082, as well as material which appears to be practically identical with sample No. 2087.

Mineral.—In the region about Mineral the residual clays are mostly of red color, but there are few good exposures. Bricks were formerly made at a yard located along the railway just east of Mineral. The excavation is not over 5 feet deep, and the yard has not been in operation for several years. The clay (Lab. No. 2081) is brownish-red, of good plasticity, but contains scattered quartz fragments, which may cause trouble in molding, if not crushed. There were also scattered schist fragments in the material. The sample tested required 44 per cent of water to give a plastic mass, and gave 9.5 per cent air shrinkage. The average tensile strength was 122 pounds per square inch.

The soft-mud bricklets had a good red color, a good ring at Cone 010, and became steel hard at Cone 03, although at this heat the shrinkage had increased considerably, and the color had become very much darker. The other tests were:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.3	28.1
05	1.3	26.6
03	7.6	12.2
1	8.0	12.4

The sudden decrease in absorption accompanying the increased fire shrinkage is quite noticeable in the above figures. A sample was put through the stiff-mud machine, but it was difficult to make the clay run through the die without tearing unless the bar was run slowly with the minimum quantity of water in the clay. This clay should make good common brick, but the best results may be obtained by molding it in a soft-mud machine.

Along the road from Mineral to Holladay, and about 400 feet south of the crossing of the Sulphur-Mine Railroad, there is a long, but rather shallow cut in the residual clay. This is tough, somewhat stony, and requires thorough disintegration before molding.

This clay (Lab. No. 2100) is fairly plastic, but mealy to the feel. It shows an air shrinkage of 7.8 per cent, and a tensile strength of 71 pounds per square inch. The clay burns red, with a fair ring at Cone 05, but not hard enough at Cone 010. It was steel hard at Cone 03.

The fire tests on the soft-mud bricklets gave the following results:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	23.0
05	.7	22.1
03	3.0	16.4
1	4.0	16.3

There is no reason why this clay should not make a red brick by the soft-mud process. A sample was tried in the stiff-mud machine, but, in spite of the plastic nature of the material, it would not flow through the die without tearing. Possibly it might work in some other style of die.

APPOMATTOX COUNTY.

Appomattox.—The bedrock around Appomattox is a micaceous schist, with many stringers of quartz up to 1 inch in thickness. So far as could be determined from surface evidence, the clay derived from the schist does

not seem to be very abundant, and in some places the bedrock comes close to the surface. The following sample (Lab. No. 2079) may serve to show the character of the clay derived from the schist.

The material is a dark red, micaceous, sandy clay of good plasticity. It had 7.9 per cent air shrinkage, and the bricklets burned at Cone 010 had a good red color, and good ring. At Cone 010 the fire shrinkage and absorption were, respectively, .3 and 27.1 per cent, while at Cone 05 they were 2 and 25 per cent.

The clay should be well adapted to common-brick manufacture.

Pamplin.—Located at Pamplin is a small plant of the Akron Pipe Company, which is making clay-pipe bowls. Two clays are used. One is a light gray clay from Ohio. The other is a yellow clay, of red-burning character, obtained from Stony Point on James River. Some clay has also been obtained from the farm of R. Davis, near Pamplin. This material while used in pipe making also seems to be adapted to other uses.

It is a very smooth and plastic clay (Lab. No. 2030), in fact it is one of the best residual clays of the Piedmont. With 23 per cent of water the mixture had an air shrinkage of 5.3 per cent, burned to a bright red color, and had an excellent ring even at Cone 010, as well as being steel hard. It also gave a product of low absorption with low fire shrinkage. At Cone 010 the fire shrinkage and absorption were, respectively, .4 and 12.8 per cent, while at Cone 05 these were 2.4 and 8.8 per cent, respectively. This clay should not only make a good common brick, but there seems a possibility of using it for hollow brick and drain tile.

There is not much clay exposed along the road from Appomattox to Pamplin, but near the latter locality there are cuts of light gray material, of which some was tested.

The clay (Lab. No. 2064) is sandy and micaceous, and not of very high plasticity. It takes less water to mix it (26 per cent) than many of the other residuals, and has an air shrinkage of 6.5 per cent. The bricklets, while of good red color, should be burned to at least Cone 05 to give a good sound product. At Cone 010 the fire shrinkage and absorption were .3 and 21.2 per cent, respectively, while at Cone 05 these were 1 and 20.8 per cent, respectively. Although this clay could be used for common brick, it does not yield a hard product at as low a cone as some of the others.

One-half mile southeast of Pamplin in a new railroad cut, about half a mile long, and with a maximum depth of 25 feet, there is a large deposit of residual clay, whose structure points to gneiss as the parent rock. This

material (Lab. No. 2086) is red, and of very fair plasticity. The air shrinkage was 8.9 per cent, a little higher probably than it would be in actual practice. The average tensile strength was 88 pounds per square inch.

The clay fired to a good red color, and the bricklets had a fair ring even at Cone 010. The color darkened somewhat at Cone 03, and considerably at Cone 1.

On firing, the soft-mud bricklets gave the following additional data:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	2.4	26.9
05	2.6	25.8
03	4.0	20.7
1	5.0	18.5

This clay should make a good common brick by the soft-mud process, and might possibly also work in a stiff-mud machine.

PITTSYLVANIA COUNTY.

Chatham.—Both the Triassic and pre-Cambrian gneiss and schist formations may serve as sources of residual clay around Chatham. Only the latter concerns us at this point. One deposit is exposed on a road, 1 mile northeast of Chatham Station. The clay is quite micaceous and was not sampled.

Another cut is about 2¼ miles north of east from the station. This section, which is about 300 feet long and 10 feet deep, shows no bedrock. The material (Lab. No. 2072) is a red-brown micaceous clay, of low plasticity. The air shrinkage is only 2.9 per cent, and the average tensile strength not over 15 pounds per square inch.

The clay burns to a red bricklet, but the product is not hard enough for service unless fired to Cone 03. At Cone 05 the fire shrinkage is 1 per cent, and absorption 25.5 per cent. At Cone 03 the fire shrinkage and absorption are 3.4 and 20.8 per cent, and at Cone 1 they are 3.6 and 22.3 per cent. The clay was tested in the stiff-mud machine, but would not flow through the die without tearing.

About half a mile farther east is another cut of residual clay from schist. And again, about 1 mile south by east from the station, is a brickyard that was operated up to about a year ago. The clay is light reddish-brown, and may be of colluvial character.

A sample of this material (Lab. No. 2067) was taken for testing. It is quite different from the other sample tested from Chatham. It worked up with 28 per cent of water to a mass of good plasticity, and had an air shrinkage of 5 per cent. The average tensile strength was 80 pounds per square inch. The bricklets burned red, and if fired to Cone 03 had a good ring.

The fire shrinkage and absorption at different cones are given below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	3.0	18.7
05	3.0	17.3
03	3.0	14.7
1	3.0	14.1

A sample was also tested in the stiff-mud machine, and flowed through both the brick and hollow-brick die without any trouble.

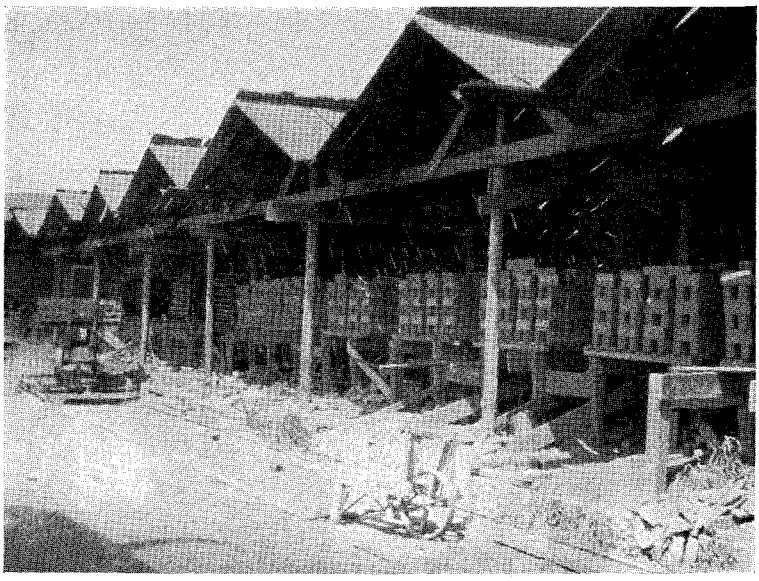
This clay could be used for manufacture of common brick and also for hollow brick. If worked in a stiff-mud machine it should first be put through a rolls to crush the scattered stones which it contains.

Danville.—The development of good brick and tile clays around Danville is of importance, partly because of local demand, and partly because it is a central point for several lines of railroad. The transported clays of this district have been referred to in an earlier page, but there still remain to be mentioned the residual clays of the pre-Cambrian gneisses and schists. These clays are widely distributed in the Danville area, and may vary considerably, according to the rock from which they are derived.

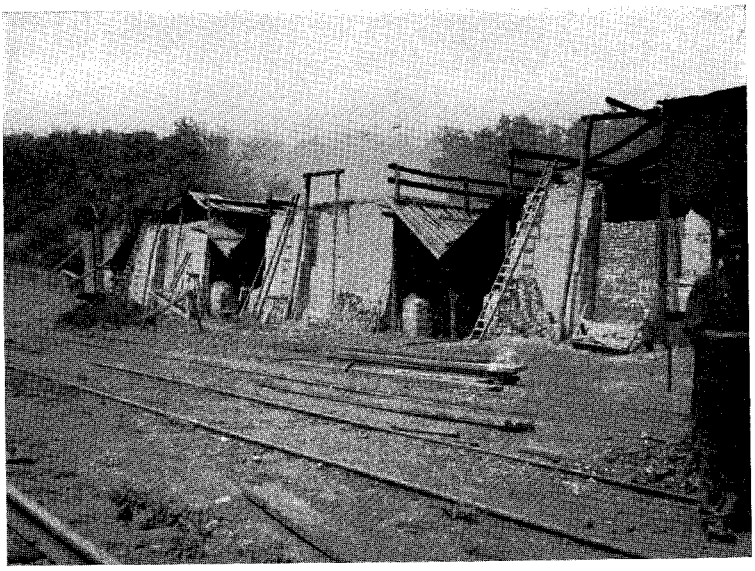
Two samples were tested, which serve to indicate the more important differences in the clays that occur in the vicinity of Danville.

Several openings have been made at Danville to obtain clay for the manufacture of brick. One of these supplies at the present time the yard of Watson and Fitzgerald. The material is derived from schist, and, at the point where worked, the thoroughly weathered rock or clay does not exceed 4 or 5 feet in depth.

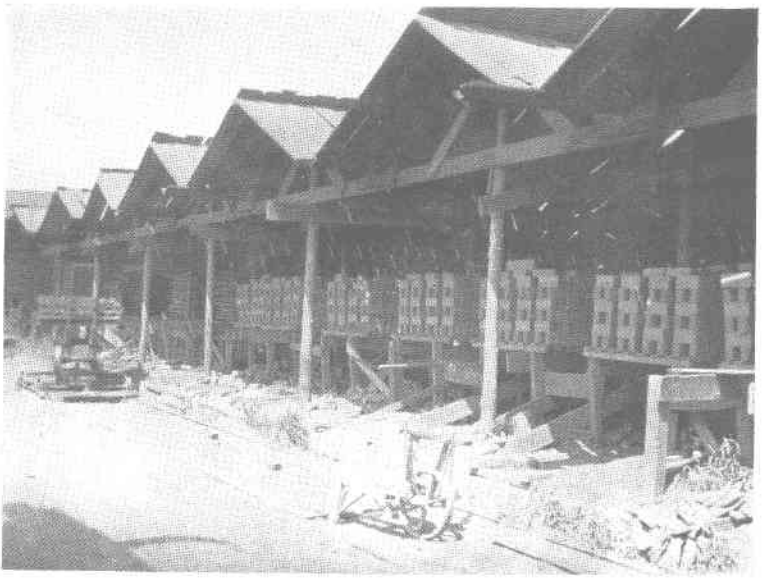
The clay (Lab. No. 2029) has good plasticity, an air shrinkage of 8.3 per cent, and an average tensile strength of 87 pounds per square inch. It burned red, and had a good ring at Cone 010. If fired at Cone 03 the shrinkage shows a noticeable increase, and the color darkens perceptibly. The bricklets burned steel hard at Cone 03.



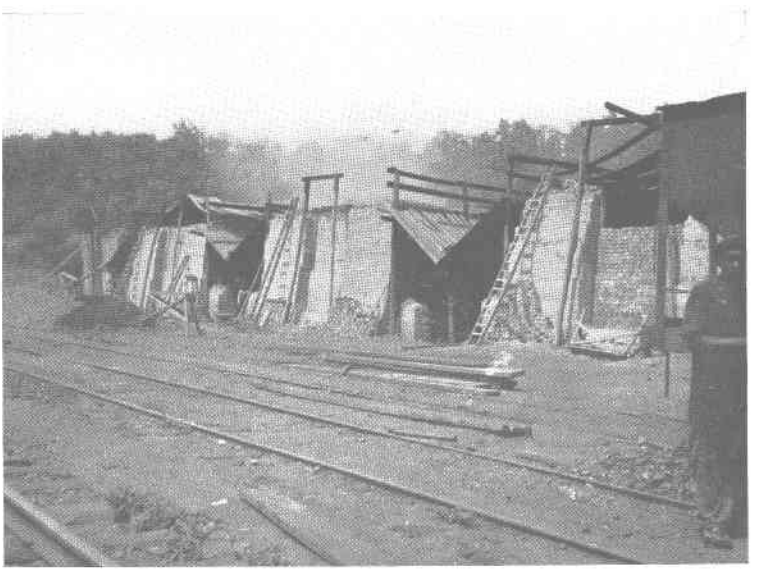
(A) Drying racks, Danville.



(B) Brick kilns, Deacon, east of Lynchburg.



(A) Drying racks, Danville.



(B) Brick kilns, Deacon, east of Lynchburg.

Other tests were as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	1.7	29.8
05	1.7	26.9
03	7.3	12.5
1	7.7	12.8

The clay makes a good common brick, and works in a stiff-mud machine as well as a soft-mud one.

Not far from Watson and Fitzgerald's yard there is obtained a whitish clay, derived from a weathered pegmatite, which is used for making boiler-setting brick.

About 6 miles west of Danville, near the trestle of the Danville and Western Railroad over Dan River, there is a shallow cut of residual clay, which is quite different from that at Danville. As the cut is shallow, the exact extent of the deposit could not be determined without boring. The material (Lab. No. 2063), although gritty to the feel, is of good plasticity. It has 6.4 per cent air shrinkage, and 94 pounds per square inch tensile strength. It burns red, and has a fair ring even at Cone 010, but does not become steel hard until Cone 03.

On firing the soft-mud bricklets they were found to have a low fire shrinkage, and moderate absorption as can be seen from the tests which follow:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	25.5
05	1.0	19.6
03	3.0	16.3
1	3.0	15.4

This is a good brick clay, and is better than the material being used at Danville at the present time.

HALIFAX COUNTY.

South Boston.—No brickyards are in operation at South Boston, although one was formerly operated near the depot. The ferruginous clays derived from schist are to be seen at a number of points, but the cuts are all too shallow to afford good samples. There seems a strong probability, however, that brick clays can be found in the vicinity of South Boston.

GRAYSON COUNTY.

Galax.—Although only transported clays are worked around Galax, residual clays are not lacking. For example, three-quarters of a mile east of Galax, on the road to Hillsville, there is a cut of red, yellow, and brown clays, which are fairly typical of the residual rock materials found in this vicinity. Indeed, there is probably considerable clay at the point where the sample was taken. The material (Lab. No. 2115) has good plasticity, burns to a red color, and at Cone 010 gives a brick with a good ring.

The air shrinkage is 5.4 per cent, and the average tensile strength 73 pounds per square inch. Further details of the tests are given below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
010	0.0	21.0
05	2.0	17.1
03	3.7	12.4

This clay should make a good common brick with the soft-mud process, and, while it was not tried in the stiff-mud machine, we believe it would work.

SUMMARY OF TESTS OF PRE-CAMBRIAN SCHISTS AND GNEISS CLAYS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Tensile strength, lbs. per sq. in.	Cone 010		Cone 05		Cone 03		Cone 1	
						Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2034	Louisa	33.0	.....	4.4	.....	0.0	23.7	0.4	20.0	.....	.....	.....	.....
2082	Louisa	24.0	.....	6.2	.....	0.0	19.1	.....	18.8	.....	.....	.....	.....
2087	Louisa	40.0	Fair	7.4	97.0	0.0	24.4	1.0	22.6	4.0	16.0	4.4	16.0
2081	Mineral	44.0	Good	9.5	122.0	1.3	28.1	1.3	26.6	7.6	12.2	8.0	12.4
2100	Mineral	.....	.....	7.8	72.0	0.0	23.0	0.7	22.1	3.0	16.4	4.0	16.3
2079	Appomattox	30.0	.....	7.9	.....	0.3	27.1	0.2	25.0	.....	.....	.....	.....
2030	Pamplin	23.0	.....	5.8	.....	0.4	12.8	2.4	8.8	.....	.....	.....	.....
2064	Pamplin	26.0	.....	6.5	.....	0.3	21.2	1.0	20.8	.....	.....	.....	.....
2086	Pamplin	44.0	.....	8.9	88.0	2.4	26.9	2.6	25.8	4.0	20.7	5.0	18.5
2072	Chatham	36.0	Slight	2.9	Not over 15.0	0.0	.....	1.0	25.5	3.4	20.8	3.6	22.3
2067	Chatham	28.0	Good	5.0	81.0	0.3	18.7	3.0	17.3	3.0	14.7	3.0	14.1
2029	Danville	43.0	Good	8.3	88.0	1.7	29.8	1.7	26.9	7.3	12.5	7.7	12.8
2063	Danville	27.0	High	6.4	94.0	0.0	25.5	1.0	19.6	3.0	16.3	3.0	15.4
2115	Galax	31.0	Good	5.4	74.0	0.0	21.0	2.0	17.1	3.7	12.4	.....	.....

Comments on the Table.

From the tabulated tests above, the clays derived from the weathering of pre-Cambrian gneiss and schist show a variable amount of water required, and are usually of good plasticity. Their air shrinkage is quite variable, but the fire shrinkage is generally low. The absorption at both Cone 010 and Cone 05 rarely falls below 20 per cent, but not a few of the clays make a sound brick.

KAOLINS.

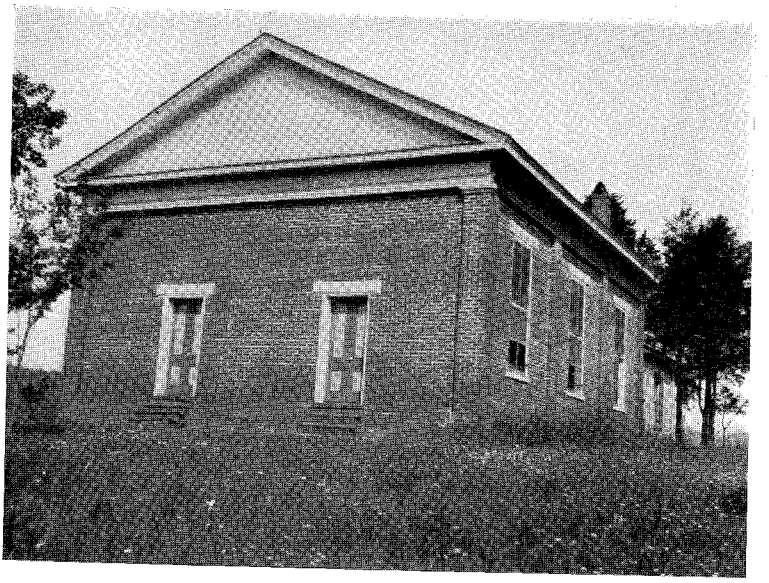
The term kaolin is properly applied to deposits of white-burning residual clay. These may be derived from the weathering of pegmatite, talcose schists, feldspathic quartzites, or granites free from iron-bearing silicates like biotite, hornblende, etc., or shales. In the Piedmont region of Virginia, only kaolin derived from the weathering of pegmatite occurs to any extent.

In the formation of kaolin from pegmatites, the feldspar weathers more or less completely to a white clay, while the white mica and the quartz resist decomposition. The crude kaolin may therefore consist of a mixture of white clay, fragments of quartz and mica, and even grains or lumps of undecayed feldspar. The depth of weathering may range from 5 or 10 feet to over 100 feet.

Such a mass in its natural condition is of little value, although it is occasionally used for fire brick, and it is therefore customary to put the clay through a washing test in order to eliminate the grit.

The method commonly followed is to disintegrate the clay thoroughly in water, after which it is run through a series of troughs of very low pitch. In its passage through the troughs the gritty particles settle out, so that when the water reaches the farther end of the troughing it contains only clay in suspension, and it is conducted into large tanks where the clay settles out. The clear water is then drawn off, and the wet clay in the bottom drawn off into filter presses where more water is squeezed out. The cakes of clay are then removed from the filter press, dried, and shipped to the factories for use.

Washed kaolins are used for several different purposes. The fine, white grades are employed in paper manufacture, and in the manufacture of white china or porcelain. For the last-named purpose they must burn white. Those which do not show an absolutely white color on burning, but exhibit a faint creamy tinge, can be employed in making C. C. ware, electrical porcelain, and sanitary ware.



(A) Church constructed of brick made from local clay and erected before the Civil War.

(B) Kaolinized pegmatite in railroad cut near Motley.

(A) Church constructed of brick made from local clay and erected before the Civil War.

(B) Kaolinized pegmatite in railroad cut near Motley.

The kaolins tested came from three localities, viz.: (1) Motley Station, Pittsylvania County; (2) northwest of Altavista, Campbell County; and (3) near Roseland, Nelson County. The first two are derived from pegmatites or coarse-grained granites, the third from a syenite.

PITTSYLVANIA COUNTY.

Motley.—One mile south of Motley, in a cut on the Southern Railway, is a vein of kaolinized pegmatite, at least 50 feet in width, inclosed between walls of schist.

The material (Lab. No. 2186) in its crude condition is very coarse grained, containing numerous flakes of muscovite and angular fragments of quartz. It is therefore not available without some form of preparation.

A sample of it was put through the crusher, with the opening set at one-eighth of an inch, and then molded into bricklets. The crushed material was of low plasticity, and had an air shrinkage of zero. The, bricklets were burned to Cone 9, and at this temperature showed 2 per cent fire shrinkage and 17.6 per cent absorption. They were also steel hard. The material might be worked in this condition to make boiler-setting brick.

Another sample was put through a washing test, and yielded 14 per cent of washed clay, which is a somewhat low return for commercial purposes. Some of the washed product was tested with the following results: Air shrinkage 4.6 per cent; color, after firing, cream-white. At Cone 1 fire shrinkage 1.7 per cent, absorption 41.5 per cent, clay not steel hard. At Cone 9 fire shrinkage 3.4 per cent, absorption 36.6 per cent, color cream-white, clay not quite steel hard.

Altavista.—On the Jackson property, 1¾ miles west of Hurt, there are several showings of kaolin, derived from pegmatite veins, cutting the pre-Cambrian rocks. The one vein visible in tunnel 300 feet south of river dips 45° N. 30° W., and is 30 to 50 feet wide. The Virginian Railway runs between Roanoke River and the tunnel, following close along the former, with the tunnel mouth about 65 feet above the track. Several small pits, dug presumably in the same vein, show much mica (muscovite), less than 1 inch in diameter. A tunnel was driven on strike of vein 45 feet, with a cross-cut halfway in, extending 32 feet from the tunnel, and exposing the footwall schist.

The material (Lab. No. 2187) is coarse-grained and contains an abundance of quartz and coarse muscovite. The material on the whole is not as coarse-grained as that described above south of Motley Station.

A sample was ground to pass through a ten-mesh sieve, and molded into bricklets. These had an air shrinkage of zero, and burned creamy white. They showed a moderate absorption, and became steel hard at Cone 9. The details of these tests are as below:

Cone	Fire shrinkage	Absorption
	Per cent	*Per cent*
03	1.0	18.5
1	1.6	16.8
9	3.3	13.7

The material in its crude form could probably be used for common fire brick, if there is enough of it.

Another lot of the material (Lab. No. 2187A) was put through a washing test, and yielded about 15 per cent of washed product, which is not a high return for commercial purposes. This had an air shrinkage of 6.6 per cent, and burned to a faint cream-white color, but appreciably whiter than the material south of Motley. At Cone 1 the fire shrinkage was 2 per cent, absorption 32 per cent, and clay not steel hard. At Cone 9 the fire shrinkage was 3.4 per cent, absorption 24.1 per cent, and product steel hard.

NELSON COUNTY.

Roseland.—The syenite which carries the rutile in this district in places appears to be quite free of quartz, rutile, and other minerals; indeed, it seems to be practically pure feldspar. There are few natural outcrops, but about three-fourths of a mile north of Roseland, on the west side of the Roseland-Bryant highway, the remains of a kaolin plant can be seen.

No operations have been carried on here for 20 years, and the workings have caved in, so that an actual exposure of the kaolin is difficult to find. From the observations that could be made, the crude material appears to contain considerable quartz, but at the west end of the outcrop, or near the old workings, there seems to be very little quartz, which is very fine grained. The washed product (kaolin) is quite mealy to the feel, as though it contained considerable sericite.

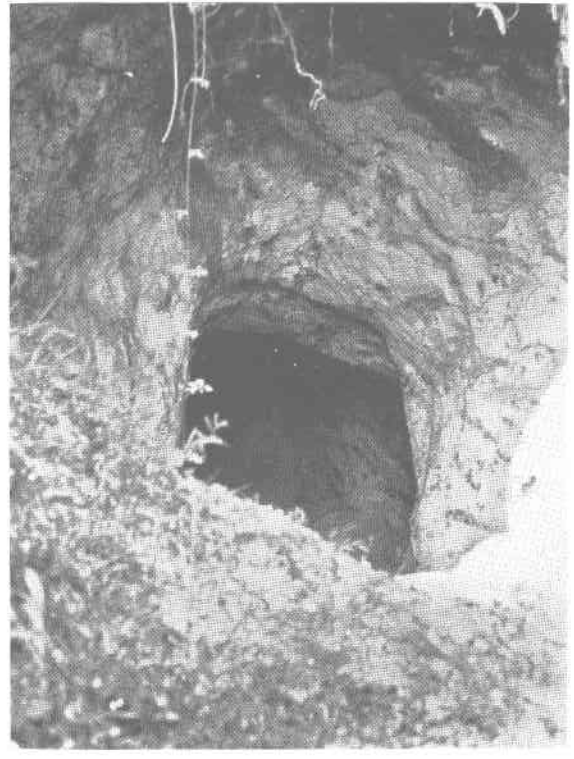
Surrounding the kaolin is a ferruginous plastic clay, evidently derived from the gabbro, and containing lumps of weathered nelsonite. The kaolin washing plant is completely dismantled, but the product is said to have been sold for paper manufacture.

A test was run first on the crude kaolin (Lab. No. 2169) to determine its properties. The crude kaolin is white, fine-grained, and passes a 100-

(A) Steamshovel excavating flood plain clay at Deacon, east of Lynchburg.

(B) Tunnel in Jackson's kaolin deposit near Altavista.

(A) Steamshovel excavating flood plain clay at Deacon, east of Lynchburg.



(B) Tunnel in Jackson's kaolin deposit near Altavista.

mesh sieve. The plasticity developed on mixing the clay with 40 per cent water is only fair, and the air shrinkage, owing to the presence of a large amount of grit, is low, 2.9 per cent. It burns white, and even at Cone 1 is nearly steel hard, but as might be expected the absorption is high, and the fire shrinkage low. Thus at Cone 010 the fire shrinkage and absorption were 1.7 and 34.7 per cent, respectively. At Cone 05 the fire shrinkage and absorption were 1 and 33.7 per cent, respectively. At Cone 1 they were 4 and 29.1 per cent. At this last cone the bricklets had a good ring.

Two samples of the washed kaolin were tested, one in more detail than the other, and the results are tabulated below, for purposes of comparison.

	2167 From stock house	2168 From stock pile at old plant
Water required	40%	27%
Air shrinkage	6%	2%
Cone 010		
Fire shrinkage	.6%	2.0%
Absorption	35.1%	34.1%
Color	Faint cream white	Ivory white
Ring	Fair	Good
Cone 1		
Fire shrinkage	2.3%	4.7%
Absorption	22.3%	21.6%
Ring	Good	Good
Steel hard	Nearly	Yes
Cone 9		
Fire shrinkage	.....	5%
Absorption	.....	19.6%
Steel hard	.....	Yes

The two samples show some differences, but, as the plant is dismantled, it is impossible to state the exact cause. The burned bricklets when dry appear nearly white, but if wet they show a distinct ivory or very faint cream tint.

A sample of No. 2167 was made into a mixture consisting of kaolin, 10 parts; flint, 4 parts; Roseland spar, 8 parts; whiting, 2 per cent. This mixture was burned at Cone 9, and gave a body that was vitrified and white, with a scarcely noticeable creamy tint.

While the kaolin can not be recommended for use in the manufacture of the whitest china, there is no reason why it should not be employed

as an ingredient in the manufacture of floor tile, electrical porcelain, and sanitary ware.

Some material which, as nearly as could be determined, appeared to represent the tailings from the old washing plant was also tested (Lab. No. 2166). It is very white and sandy, but contains some reddish spots of the surrounding residual clay scattered through it. Its plasticity is naturally very low, and took only 27 per cent of water to mold it. The air shrinkage is also low, 1.1 per cent.

Only a few fire tests were made on it. These showed a very low fire shrinkage up to Cone 1. An absorption of 27.5 per cent at Cone 010, and of 22.6 per cent at Cone 1. At the latter cone it is nearly steel hard.

SUMMARY OF TESTS OF KAOLINS.

Laboratory No.	LOCALITY	Water required for mixing	Plasticity	Air shrinkage	Cone 010		Cone 05		Cone 03		Cone 1		Cone 9	
					Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption	Fire shrinkage	Absorption
		Per Cent		*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
2186	Motley, crude	.....	Low	0.0	.....	.....	.....	.....	.....	.....	.....	.....	2.0	17.6
2186-A	Motley, washed	.....	.....	4.6	.....	.....	.....	.....	.....	.....	1.7	41.5	3.4	36.6
2187	N. W. Altavista	20.0	.....	0.0	.....	.....	.....	.....	1.0	18.5	1.6	16.8	3.3	13.7
2187-A	Same, washed	.....	.....	6.6	.....	.....	.....	.....	.....	.....	2.0	32.0	3.4	24.1
2169	Roseland, crude	40.0	Fair	2.9	1.7	34.7	1.0	33.7	.....	.....	4.0	29.1	.....	.....
2166	Roseland, tailings	27.0	Very Low	1.1	.....	.....	0.0	27.5	.....	.....	1.3	22.6	.....	.....
2168	Roseland, washed	27.0	Very Low	2.1	2.0	34.5	.....	.....	.....	.....	4.3	24.2	5.0	19.6
2167	Roseland, washed	40.0	Low	6.0	0.6	35.1	.....	.....	.....	.....	2.3	22.3	.....	.....

OTHER KAOLIN DEPOSITS.

Deposits of kaolin have been found at several other points in the Piedmont province, but none of them is being worked at the present time.

In 1904 a kaolin deposit was worked near Oak Level, Henry County. The kaolin is formed by the weathering of pegmatite dikes that cut the schists of the district. It was mined from circular pits, some of which were 80 feet deep. A washing plant was built and operated near the deposit.

The mica-bearing pegmatites around Ridgeway, Henry County, are frequently kaolinized to a depth of from 10 to 50 feet, but the material is not only too impure for white-ware manufacture, but is not found in sufficient quantity for working.

A kaolin prospect, 6 to 15 feet wide,[a] is known to occur one and a quarter miles northeast of Forest, Bedford County. It is said to yield 27 per cent of washed material, which has an air shrinkage of 6.2 per cent, and at 1350°C a fire shrinkage of 16.4 per cent.

THE CLAYWORKING INDUSTRY OF THE VIRGINIA PIEDMONT PROVINCE AND ITS FUTURE.

The clays of the Virginia Piedmont province are at present developed to a comparatively small extent. Small brick yards are in operation at a number of points, and are run chiefly to supply a local demand, but around some of the large towns, like Lynchburg and Danville, several plants have been established. Future developments will probably be most successful, if started in the southern half of the Piedmont province, as the northern portion is easily supplied by the many yards of the Alexandria (Virginia) district.

The results of the tests given in the preceding pages show that there are many deposits of clay that can be successfully utilized for the manufacture of common brick by the soft-mud, or, in many cases, by the stiff-mud process. The sandy nature of many of the deposits precludes their being employed for the manufacture of dry-press brick. This same character requires that the clay should be well burned in order to get a product of the proper hardness, a fact that has been neglected by some.

Of the several classes of clays tested, the transported ones found along the rivers yield the strongest and the densest brick. Next to these come the

[a] Watts, S. A., Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian Region, Bull. 53, Bureau of Mines, 1914, 101 pages.

Triassic residual clays, one of which, from Wolftrap, Halifax County, is very plastic and dense burning. Some of the residual clays of the Cambrian formations, notably those near Gordonsville, Orange County, are very promising, and those derived from the volcanic rocks near Virso, Lunenburg County, yielded good results.

Of greatest areal extent are the residual clays from the granites and gneisses, and these often possess excellent plasticity. They burn to a good color and a moderately hard body, but the absorption is not as low as desired. The residual clays from the Catoctin schists (metamorphosed pre-Cambrian basalt) are less promising.

The tests also show that some of the residual clays can be applied to the making of hollow brick, and the same is true of the Triassic clays, especially those near Wolftrap, which in addition can be made into drain tile.

Attention should also be called to the kaolin deposits of Nelson County, which probably exist in some quantity. As pointed out, they can be utilized in the manufacture of certain grades of white ware.

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GEOLOGIC MAP
OF THE
CRYSTALLINE REGION
(PIEDMONT PLATEAU AND BLUE RIDGE MOUNTAINS PROVINCES)
OF
VIRGINIA
SHOWING CLAY LOCALITIES

GEOLOGY
FROM A GEOLOGICAL MAP OF VIRGINIA
BY THOMAS L. WATSON, 1916

CLAY LOCALITIES
BY
H. RIES AND R. E. SOMERS

BASE MAP OF VIRGINIA COMPILED IN 1914 IN COOPERATION WITH
THE U. S. GEOLOGICAL SURVEY

1917

Scale
0 10 20 30 40 50 Miles
0 10 20 30 40 50 Kilometers

LEGEND

MESOZOIC
TRIASSIC
Sandstones, conglomerates, shales, coal beds, and diabase

PALEOZOIC
CARBONIFEROUS
Anthracite fields
Bituminous fields
Undifferentiated Carboniferous

DEVONIAN
Shale of the Chattanooga formation

SILURIAN
Clinton, Medina, and Tuscarora formations

ORDOVICIAN
Trenton limestone and Utica shale

CAMBRIAN
Shenandoah limestone

PRECAMBRIAN
Unclassified sedimentary rocks
Volcanic and intrusive igneous rocks
Gneiss, schist, quartzite, marble, and other crystalline rocks

Clinton iron ore and gneiss, chiefly of Grenville age, and their igneous equivalents

Locality of clay sample listed

CLAY LOCALITIES

Indicated on the map by dots and numbers

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1	2015	Orange	29
2	2016	Montpelier Mills	21
3	2032	Montpelier	21
4	2008	Orange	31
5	2009	Orange Run	31
6	2007, 2006	Culpeper	41
7	2013	Culpeper	16
8	2012	Culpeper	16
9	2030	Brandy	19
10	2033	Shenandoah	40
11	2031	Shenandoah	40
12	2023	Warrenton	24
13	2022	Cabin Branch Mine, Dumfries	24
14	2021	Amissville	24
15	2020	Amherst	41
16	2027	Amherst	41
17	2026	Amherst	41
18	2025	Bedford	42
19	2098	Bedford	42
20	2095, 2091	Danville	24
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22	2028	Danville	24
23	2097	Wolfburg	24
24	2038	Drakes Branch	24
25	2037	Drakes Branch Junction	24
26	2035, 2036	Virginia	27
27	2034	Arvonia	27
28	2024	Arvonia, new Cannon and Brown Shaft	28
29	2024, 2025	Arvonia	28
30	2096	Parrsville, north of Arvonia	30
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37	2019	Culpeper	40
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40	2016	Culpeper	40
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