



COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION  
AND ECONOMIC DEVELOPMENT

DIVISION OF MINERAL RESOURCES

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ANALYSES OF CLAY, SHALE  
AND RELATED MATERIALS —  
NORTHERN COUNTIES

James L. Calver, Howard P. Hamlin and  
Robert S. Wood

In Cooperation with U. S. Bureau of Mines

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MINERAL RESOURCES REPORT 2

VIRGINIA DIVISION OF MINERAL RESOURCES

James L. Calver

Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA

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DEPARTMENT OF PURCHASES AND SUPPLY  
RICHMOND  
1961

DEPARTMENT OF CONSERVATION AND  
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# **ANALYSES OF CLAY, SHALE, AND RELATED MATERIALS—NORTHERN COUNTIES**

By

**JAMES L. CALVER, HOWARD P. HAMLIN  
and ROBERT S. WOOD**

## **ABSTRACT**

Descriptions of tests used in the evaluation of clay materials for possible commercial utilization are discussed. The report contains tests and determinations of properties required to evaluate the potential ceramic and nonceramic uses of 111 samples of clay, shale, mudstone, slate, phyllite, and schist. The localities sampled are in the following counties in Virginia: Clarke, Culpeper, Fairfax, Fauquier, Frederick, Greene, Loudoun, Madison, Orange, Page, Prince William, Rappahannock, Rockingham, Shenandoah, Spotsylvania, Stafford, and Warren.

## **INTRODUCTION**

In November 1957, the Virginia Division of Mineral Resources entered into a cooperative agreement with the United States Bureau of Mines to promote effective coordination of activities for exploration and evaluation of clays and similar non-metallic materials for ceramic and other uses. The responsibilities of the Virginia Division of Mineral Resources include the planning and conducting of field work, the correlation of field, geological, and laboratory data, and the sampling and delivery of clay samples to the Norris Metallurgy Research Laboratory, Norris, Tennessee. Under the agreement the responsibility of the Bureau of Mines is to make appropriate tests and determinations of properties required to evaluate the potential ceramic and non-ceramic uses of the samples. This publication contains the determinations for 111 samples

collected from localities in the northern portion of Virginia (Figure 1). Occurrences of clay, shale, mudstone, slate, phyllite, and schist were sampled and were found to have properties that meet the specifications of materials used in the manufacture of common and decorative face brick, tile, refractories, low grade pottery, and lightweight aggregate.

The Coastal Plain province contains clays that are suitable for the manufacture of brick, tile, and other structural clay products. Some of the clay from Stafford County is suitable for use in low duty fire brick.

Samples of slate, schist, and phyllite from localities in the Piedmont province were determined to be suitable for brick manufacture. Shales and mudstones were found to be satisfactory for brick and tile, and, in some localities for lightweight aggregate. Clay from one locality in Loudoun County was determined to be suitable for low grade pottery, and from one locality in Prince William County, for brick and tile.

Several localities of shale that have characteristics suitable for structural clay products and lightweight aggregate were found in the Ridge and Valley province. The Martinsburg shale, Romney shale, Marcellus shale, Hamilton shale, Brallier shale and the Chemung shale have characteristics that are usually satisfactory for brick and tile. Samples of Brallier shale from two localities in Rockingham County and of Hamilton shale from one locality in Shenandoah County have properties suitable for the manufacture of lightweight aggregate. Samples from one locality of Millboro shale, Rockingham County, have properties that indicate a potential use for decorative brick. The unweathered Martinsburg shale offers a source of raw material for lightweight aggregate.

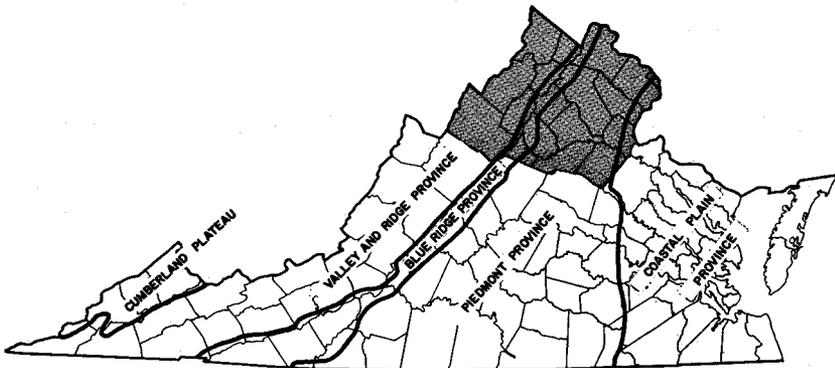


Figure 1. Area of investigation.

gate. The weathered shale may expand only slightly or remain virtually unchanged during firing. This difference in bloating characteristics is apparently related to the ferrous (FeO) and ferric (Fe<sub>2</sub>O<sub>3</sub>) iron content of the shale. The unweathered shale contains ferrous iron that oxidizes to ferric iron during the weathering process. Ferrous iron, a more powerful fluxing agent than ferric iron, promotes fluxing at lower temperatures than does the ferric iron. The unweathered shale expands readily and fuses at temperatures favorable for the entrapment of gases.

Two samples collected from a calcareous phase of the Martinsburg shale were found to be unsuitable for any type of ceramic product. X-ray analysis indicate calcium has replaced the iron, potassium, and sodium content of the shale. If the Martinsburg shale contains appreciable amounts of limestone or other calcareous materials, additional sampling should be done because calcium carbonate alters the firing characteristics appreciably.

A word of caution: the evaluation remarks are based on test data determined on one or two samples from each locality. Detailed exploration, sampling and tests should be carried out to prove any particular locality for commercial development. Likewise, test results of a single sample from an existing pit or stock pile may not be representative of all the material. Samples from other parts of the pit, stock pile, or other locations of the same formation may not have the same physical and chemical characteristics as determined for the sample that was tested.

## EVALUATING CLAY MATERIALS

Clay is a major raw material in a wide variety of ceramic products and is also used for many non-ceramic purposes. Aside from the basic physical and chemical properties that clays must possess, the extent or degree of clay beneficiation and the availability of materials for blending purposes must be considered when evaluating clays for possible commercial utilization. Many clays are used as obtained from the deposit; others must be beneficiated or refined to remove objectionable impurities. Clay must possess certain properties for each use, and a property that is considered essential for one product may be wholly unimportant in another. To test each sample for all uses would be impractical, and fortunately, for a preliminary appraisal is unnecessary. The testing is exploratory and gives clay type, properties, and possible uses. Such preliminary evaluations are valuable to indicate the potential uses for the clay and to determine whether further tests are warranted.

When the preliminary data were not conclusive enough to warrant a reliable appraisal of a sample, specific tests were made to obtain the necessary data to complete the evaluation. In order to correlate the test data with the geological information, 27 x-ray and petrographic analyses were made on materials from 13 different rock formations or materials of different geologic ages. If the unfired and fired properties of the samples indicated significant differences in mineral composition, as in the case of the Brallier and Martinsburg shales and the shales of Triassic age, additional x-ray and petrographic analyses were made.

Some of the ceramic and non-ceramic uses for which clays are evaluated are:

<u>CERAMIC</u>	<u>NON-CERAMIC</u>
Whiteware	Fillers for plastic
Structural products	Additives in paint, paper, rubber, etc.
Refractory products	Abrasives
Artware or pottery	Oil clarifiers
Lightweight aggregate	Foundry molds
	Drilling muds
	Pigments

## CERAMIC USES

### GENERAL TESTING PROCEDURE

A two-pound representative sample of the material is dried at 230°F and ground fine enough so that 100 per cent passes 20 mesh sieve. One hundred grams of the dried clay is mixed with water (measured) to form a plastic mass. The working properties of the clay are noted and small test specimens (approximately 1½" x 2½" x ¼") are fabricated in a steel mold or die. The test specimens are marked for shrinkage, dried at 140°F for 12 hours, then dried at 230°F for an additional 12 hours. Six of the dried specimens are placed in a laboratory kiln, and the temperature is raised slowly to prevent disintegration when the mechanically and chemically combined water is released. Approximately three hours are required for the kiln to reach 1800°F. Test specimens are removed from the kiln at 1800°, 2000°, 2100°, 2200°, 2300°, and 2400°F, after a 15-minute soak at each temperature. About 4 hours are required to cover the 1800° to 2400° range; these temperatures cover the range encountered in most ceramic firing and are adequate for general appraisals.

The method described for making the test specimen is essentially the soft mud process, and in it the amount of water used for achieving plasticity is higher than in the stiff mud process that is normally used in commercial production. Firing shrinkages are also higher since the clay is not de-aired and the forming pressure is much less.

From the general testing procedure the following data are accumulated. Characteristics of unfired material include color, pH, unfired strength, plasticity, workability, water of plasticity, drying properties (shrinkage, warping, or cracking) and soluble salt content. The characteristics of fired material include color, hardness, shrinkage, percent absorption, and apparent specific gravity. Further tests are made as warranted by the analyses of the data.

The various methods and procedures used in testing the samples in this report are described in detail (Klinefelter and Hamlin, 1957). A. S. T. M. designations of specifications and tests related to structural clay products are contained in the References.

#### WHITEWARE CLAYS

With few exceptions, kaolins and ball clays are the two types of clays used in whiteware. These materials, which must fire white to qualify for this use, are readily detected by the general testing procedure. The data from the general tests usually distinguishes the ball clays from the kaolins, and indicates whether beneficiation is required to remove excessive quartz, mica, and other impurities from the samples.

As a rule, the information obtained from preliminary tests is adequate for a general appraisal. If more specific information is required, however, further tests are made by using the clay in a standard whiteware body to determine its casting, extrusion, and jiggering properties.

Criteria used for judging whiteware materials are listed in Table 1.

#### STRUCTURAL CLAYS

The names of common clays used for structural products are frequently derived from the nomenclature of the product. This is often confusing because product names vary from one section of the country to another; processing terms are often added to the name, and the architectural application may also be used with the name.

Table 1.—Criteria used for evaluating whiteware materials

	BALL CLAYS	KAOLINS
	<i>Unfired properties</i>	
Workability or plasticity	Very plastic, sticky, and smooth working	Very plastic to fairly plastic and smooth working
Grit, mica, sand	Excessive amount indicates beneficiation	Excessive amount indicates beneficiation
Green dry strength	Very high	Low
Color	Not critical	Not critical
	<i>Fired properties</i>	
Color	White to off-whites (Faint ivory or gray to cream) (Acceptability by consumer)	White to off-white
Fusion point (Pyrometric cone equivalent)	Cone 30 and higher	Cone 33—35

The use of architectural and processing terms with the product name is shown by such terms as fireplace tile, chimney flue tile, decorative face brick, hollow wall tile, back-upbrick, inlaid tile, sand-finished brick, glazed brick, pressed brick, and scored brick. Floor tile varies in size from one section of the country to another; in the south it is often called quarry tile; in the west, patio tile; and in other sections, ceramic floor tile. It is not practical to give all the names associated with structural clay products. A simplified listing of the more common products and the raw materials normally used in making them is given in Table 2 (Wilson, 1928).

#### PROPERTIES OF STRUCTURAL CLAYS

Structural clay products are made from a wide range of clays, and the properties of these clays vary in importance with the product and the method of processing. While the dry press and soft mud processes are sometimes used in fabrication, the most common method employed is the stiff mud extrusion process. In this process, workability (plasticity) is the most important property of the raw material. The clay is extruded under considerable pressure and should flow smoothly in a column from the die without undue lamination or other defects. Overly plastic clays tend to laminate when extruded, whereas non-plastic clays do not extrude in a smooth column.

The clay must dry uniformly at a reasonable rate without warping and cracking. Fine sand or grog is sometimes added to clays that have poor drying characteristics. This improves the drying rate and also decreases the drying and firing shrinkages.

Table 2.—Structural clay products

Product Raw material	Fired color	Description of product	Uses
Common brick clays and shales	Reds to red-brown	Under fired or off-color brick	Backing up masonry walls
Face brick clays and shales	Creams, buffs, reds, browns (various scored, glazed, etc., finishes)	Uniform attractive colors, textured finishes	Facing walls
Decorative brick clays and shales	Unusual colors, pinks, buffs, grays, etc.	Mottled and spotted	Facing walls and special applications, such as interior and exterior decorations
Hollow tile clays and shales	Not critical, usually reds, buffs, brown-reds	Rectangular, four holes	Back up for hollow wall construction
Wall tile clays and shales, talcs, etc.	White, buffs, etc. glazed to any color	Flat squares	Interior wall (facings, etc.)
Drain tile clays and shales	Buff to red-brown	Porous, circular shapes	Septic fields and water drainage around subur- ban housing develop- ments
Roofing tile clays and shales	Buff, reds, browns	Corrugated or channeled	Roofs
Floor tile clays and shales (can be synthetic mixes)	Various colors	Vitrified, dense	Floors and patios
Chimney flue tile clays and shales, low grade fire clays	Buff, reds, and red-brown	Hollow cross sections, re- fractory	Lining of chimneys
Terra cotta clays and shales, buff burning, 25-50% cal- cined material	Various	Variety of shapes and colors, hollow construction, glazed and unglazed	Facing walls, interior and exterior decoration
Electrical conduit clay and shales	Buff, reds, and brown	Square sectional, vitrified	Conduit for underground electrical wiring
Sewer pipe clays and shales	Reds, red-brown	Usually salt glazed, circu- lar with flanged end	Sewer drainage
Lightweight aggregate clays and shales	Light to dark colors	Expanded or bloated par- ticles	Lightweight concretes, blocks, etc., for back up

Clays must develop adequate green strength so that the ware can be handled in the unfired state. The importance of this property has declined to some extent due to the development of organic binders. These binders have made it possible to utilize many raw materials that do not possess adequate natural green strength for clay products.

The importance of fired color varies from one structural product to another. Through the use of mineral pigments, fired colors can be controlled to some extent, and the natural color of the fired clay can be augmented by the addition of pigments to produce more desirable colors.

The blending of two or more clays to produce structural products has become a fairly common practice in the past few years. Each clay is selected because of certain desirable properties. For example, one clay may have exceptionally good working properties, but high shrinkage and poor fired colors, whereas another may have poor working characteristics, low shrinkage, and a good color range. A combination of the two will give a satisfactory product, and by varying the amounts of each clay a much wider range of colors can be obtained.

The criteria used for evaluating structural clays are given in Table 3.

Table 3.—Criteria used in evaluating structural clays

	Common brick 1	Face brick 2	Decorative brick 2A	Hollow tile 3	Wall tile 4	Drain tile 5	Roofing tile 6
<i>Unfired properties</i>							
Workability	Fairly plastic to plastic	Fairly plastic to plastic	Fairly plastic to plastic	Plastic to very plastic and smooth			
Water of plasticity %	15—40.0	15—40.0	15—40.0	0—35.0	0—35.0	15—40.0	0—35.0
<i>Green strength</i>							
Wet and dry	Low to high	Low to high	Low to high	Average to high	Average to high	Average to high	Average to high
Drying characteristics	No warping or cracking	No warping or cracking	No warping or cracking	No warping or cracking	No warping or cracking	No warping or cracking	No warping or cracking
Drying shrinkage %	0—12	0—12	0—12	0—8	0—8	0—8	0—8
<i>Fired properties</i>							
Maturing temp. °F	1800—2000	1800—2200	18—2200	1800—2100	1800—2100	1800—2000	1800—2200
Hardness	Very hard to steel hard	Steel hard	Steel hard	Steel hard	Steel hard	Very hard	Steel hard
Absorption %	Up to 20	Up to 15	Up to 15	Up to 15	0—10	1—12	0—10
Shrinkage %	0—10	0—10	0—10	0—10	0—10	0—8	0—8
Color	Reds dark reds, red-browns	Reds, buff; creams, etc.	Unusual, mottled colors, pinks, grays, etc.	Not too critical	Reds, buff, creams, off-whites	Not critical	Reds, buff, dark browns
Scumming*	Slight	None	None	Slight	None	Slight	None

Table 3.—Criteria used in evaluating structural clays (continued)

	Floor tile 7	Chimney tile 8	Terra cotta 9	Conduit 10	Sewer pipe 11	Lightweight aggregate 12
<i>Unfired properties</i>						
Workability	Plastic to very plastic and smooth	Plastic to very plastic and smooth	Very plastic and smooth	Very plastic and smooth	Plastic to very plastic and smooth	
Water of plasticity %	0—35.0	15—40.0	18—35	15—40.0	0—35.0	
<i>Green strength</i>						
Wet and dry	Average to high	Average to high	Average to high	Average to high	Average to high	See section
Drying characteristics	No warping or cracking	No warping or cracking	No warping or cracking	No warping or cracking	No warping or cracking	"Lightweight Aggregate Clays"
Drying shrinkage %	0—8	0—8	Up to 8.0	0—4	0—8	page 12
<i>Fired properties</i>						
Maturing temp. °F	1800—2200	1800—2400	2000—2200	1800—2200	1800—2100	
Hardness	Steel hard	Very hard	Steel hard	Steel hard	Steel hard	
Absorption %	0—20	0—20	8—25	0—4	0—8	
Shrinkage %	0—8	0—8	0—8	0—10	0—10	
Color	Reds, buffs, dark browns	Not critical	Reds, buffs, gray-buffs, off-whites	Not critical	Usually reds	
Scumming*	None	None	None	None	None	

\*Scumming indicates soluble salts, slight scumming can usually be corrected by adding BaCl<sub>2</sub> or BaCO<sub>3</sub>.

## POTTERY CLAYS

In evaluating clays for pottery, fired color and workability are the most critical properties. Stoneware clays, buff- to red-burning clays, whiteware clays and bodies are used in making pottery. The ware is formed either by slip-casting, jiggering, or throwing. If the ware is formed by throwing or jiggering the clay must have above average plasticity. As a general rule, the more plastic clays have better slip-casting properties because they are usually finer grained than the less plastic ones.

While a single clay may be used for making pottery, most of it is made from blends of clays, potters flint, and fluxing materials, thus the working characteristics, drying and firing shrinkages, fired colors, and maturing temperatures can be more or less, controlled by selecting the proper clays.

If a single clay is used for pottery, the drying and firing shrinkage must not be excessive enough to cause warping or cracking. When pottery is made from blends, the shrinkage of the clay is not so critical because the composition of the blend can be varied to control the shrinkage. For example, ball clays used in making pottery have very high drying and firing shrinkages. These clays are used because they improve the workability of the body and increase the strength of the ware in the green and fired states.

Another reason why the shrinkage in pottery clay is not too critical is because the dimensions of the fired ware can be adjusted by regulating the size of the plaster molds used in forming the pieces. The principal pottery types and the criteria for evaluating pottery clays are listed in Tables 4 and 5.

Table 4.—Principal types of pottery

	Fired Colors	Uses
<i>Whiteware</i>		
Mixes of white burning clays, feldspars, flint, etc.	White (colors obtained by glazes, body pigments, etc.)	Table ware, sanitary ware, porcelain, etc.
<i>Stoneware</i>		
Gray to buff clays	Variety of colors, glazed and decorated	Kitchen ware, chemical stoneware, etc.
<i>Earthenware</i>		
Red-buff burning clays	Red to buff, glazed and unglazed	Kitchenware, gardenware, etc.
<i>Artware</i>		
Various clays	Variety of colors, glazes and decorations	Decoration

Table 5.—Criteria for evaluating pottery clays

	Whiteware 1	Stoneware 2	Earthenware 3	Artware 4
<i>Unfired properties</i>				
Workability	Highly plastic and smooth working Not critical	Highly plastic and smooth working Not critical	Very plastic and smooth working Not critical	Very plastic and smooth working Not critical
Water of plasticity	Not critical	Not critical	Not critical	Not critical
<i>Green Strength</i>				
Wet and dry	Average	Above average	Average	Above average
Drying characteristics	Dry free from defects under controlled drying	Dry free from defects at normal drying rates	Dry free from defects at normal drying rates	Dry free from defects at normal drying rates
Drying shrinkage	See discussion on properties of pottery clays	See discussion on properties of pottery clays	See discussion on properties of pottery clays	See discussion on properties of pottery clays
<i>Fired properties</i>				
Maturing temp. °F.	1800-2500	2100-2300	1800-2200	1800-2100
% Shrinkage	See discussion on properties of pottery clays	See discussion on properties of pottery clays	See discussion on properties of pottery clays	See discussion on properties of pottery clays
% Absorption (unglazed)	0-2	0-2	0-5	Not critical
Colors	Whites, blues, yellows, etc.	Buff and grays	Reds, browns, and buffs	Variety

## LIGHTWEIGHT AGGREGATE CLAYS

The clays utilized for lightweight aggregate are of the common variety. Either the rotary kiln or sintering method is employed in processing these clays, and the processing method will vary with the properties of the clays. For the rotary kiln process the clay should dry readily without undue disintegration and should show good expansion when heated rapidly. If the sintering process is used, the clay should vitrify at about 2200°F. with slight expansion and the particles should have a slightly glazed exterior.

To test clays for lightweight aggregate manufacture requires a different procedure than that used for other structural clay products. The procedure used is as follows: Five pounds of the clay is dried overnight at 230°F. The sample is then crushed with a roll or jaw crusher set at  $\frac{1}{2}$ -inch and a screen analysis is made of the crushed material. A laboratory kiln (Plate 1) is heated to 1800°F, and 20 grams of the ( $-\frac{1}{2} + \frac{1}{4}$  inch size) clay on a refractory slab (or boat) is inserted in the kiln for 15 minutes and then removed. This process is repeated at 1900°, 2000°, 2100°, 2200°, 2300°, 2400°F, or until the clay becomes very sticky and begins to melt.

The expanded aggregate is tested for weight and percent absorption and is examined as to general structure and appearance. During the firing of the clay, the temperature at which sticking or melting occurs is noted.

Although the general testing procedure gives data useful in appraising clays for lightweight aggregate, the final evaluation is based on data obtained from quick firing tests designed to approximate commercial operating conditions. Table 6 gives the criteria for evaluating lightweight aggregate clays.

Table 6.—Criteria used in evaluating lightweight aggregate clays

	Rotary kiln process	Sintering process
<i>Unfired properties</i>		
Drying characteristics	Dry readily and show only slight disintegration when bloating test is made	Not critical, water used to pelletize before firing
Dry strength	Strength must be sufficient for proper sizing when crushed for kiln feed	Not critical
Crushing characteristics	-8 mesh material should not exceed 20%, see additional discussion in text	Not critical except where particles tend to be thin and platy
<i>Fired properties</i>		
Firing range	1800-2200°F	Vitreous and glazes between 2200-2300°F
Bloating range	Minimum 100°F, 200° preferred	.....
Weight	75-45 lb/ft <sup>3</sup>	After clay is sintered, weight sintered, weight 75-45 lb/ft <sup>3</sup>
Expansion	Gradual weight decrease thru bloating range	Slight
% Absorption	0-18.0 at best bloating temp.	0-6.0
Color	Light reds to light grays preferred, although color not too critical	Light red-grays preferred although color not too critical
Strength	This must be determined by concrete performance test	.....

## CRUSHING CHARACTERISTICS

In rotary kiln processing the crushing characteristics of the raw material are of considerable importance. The properties of the expanded aggregate and the behavior of the raw material as it passes through the rotary kiln are influenced by the size, shape, and thickness of the particles. As a general rule, if the kiln feed contains an excess of 10 percent —8 mesh particles, sticking occurs, because the fine material over-fires and becomes viscous as the heat penetrates the smaller sizes much faster than it does the coarser material. Fine particles in soft clays are not too serious, because they can be removed by screening and then may be stockpiled until they gain enough moisture to recompact sufficiently for re-use. The fine particles from harder clays (shales and slates) do not compact naturally and must often be discarded as waste material. If the screen analysis of a sample shows excessive fine particles, a further study of the crushing characteristics should be made to see whether different crushing techniques will decrease the percentage of fine material.

The influence of particle thickness on the expansion characteristics of a bloating material can best be explained by a brief discussion of the bloating process. When a particle expands under heat treatment the exterior becomes sufficiently pyroplastic or melted to entrap the gases generated by the decomposition of the various compounds on the interior. Thin particles tend to heat all the way through so that the gas-producing compounds are decomposed before the exterior becomes sufficiently pyroplastic to entrap the gases that produce the expansion.

Although the retention time that is required for the expansion of a given material may be determined by the preliminary testing procedure, a rotary kiln test is essential to show the effect of particle shape on the processing characteristics.

The crushing characteristics of clays that are to be sintered are not critical because the clay is mixed with coal or coke and pelletized before processing.

## FIRING CHARACTERISTICS

For rotary kiln processing, a wide range is desirable between the temperatures at which the clay expansion begins and at which sticking occurs. Good bloating clays have a bloating range of 200°F or more, and clays with less than a 70°F range are not suitable for the rotary kiln method of lightweight aggregate production.

The weights of the expanded aggregate at the various temperatures are indicative of the uniformity of expansion. Good aggregate clays show a gradual decrease in weight as the temperature increases, and, as a general rule, clays that show abrupt weight changes are not amenable to the rotary kiln method of processing.

Laboratory testing and evaluating of clays for lightweight aggregate has proven to be of greater value for rotary processing than for sintering. The tests for sintering properties are less accurate and in most cases the true evaluation can be accomplished only by making small scale sintering tests.

## REFRACTORY CLAYS

The most important property to be considered in appraising refractory clays is refractoriness. Other properties vary in importance with the method of fabrication and the specific use. Blends of clays are used in making most refractory products and the ware may be formed by dry pressing, extruding, casting, or hand molding. If the ware is to be formed by hand molding, the blend of clays should have good plasticity. Thus the desirable properties of unfired clays used in making the blend, such as plasticity, green strength (wet and dry), and drying characteristics, vary to some extent, by the method of fabrication.

If the ware is to be formed by hand molding, the blend of clays used would naturally have to have good plasticity, thus the unfired properties of the clays used in making the blend, such as plasticity, green strength (wet and dry) drying characteristics will determine, to a large extent, the method of fabrication. Some of the more common names associated with refractory clays are flint clays, semi-flint clays, coal measure fire clays, high alumina clays, plastic fire clays, and refractory bond clays. Such names as crucible pot, retort, and sagger are used by the trade to indicate a fire clay of certain characteristics that is suitable for a specific use.

In a preliminary evaluation of a refractory clay, the general testing procedure distinguishes the plastic clays from the non-plastic clays and gives other properties such as shrinkage, absorption, and apparent specific

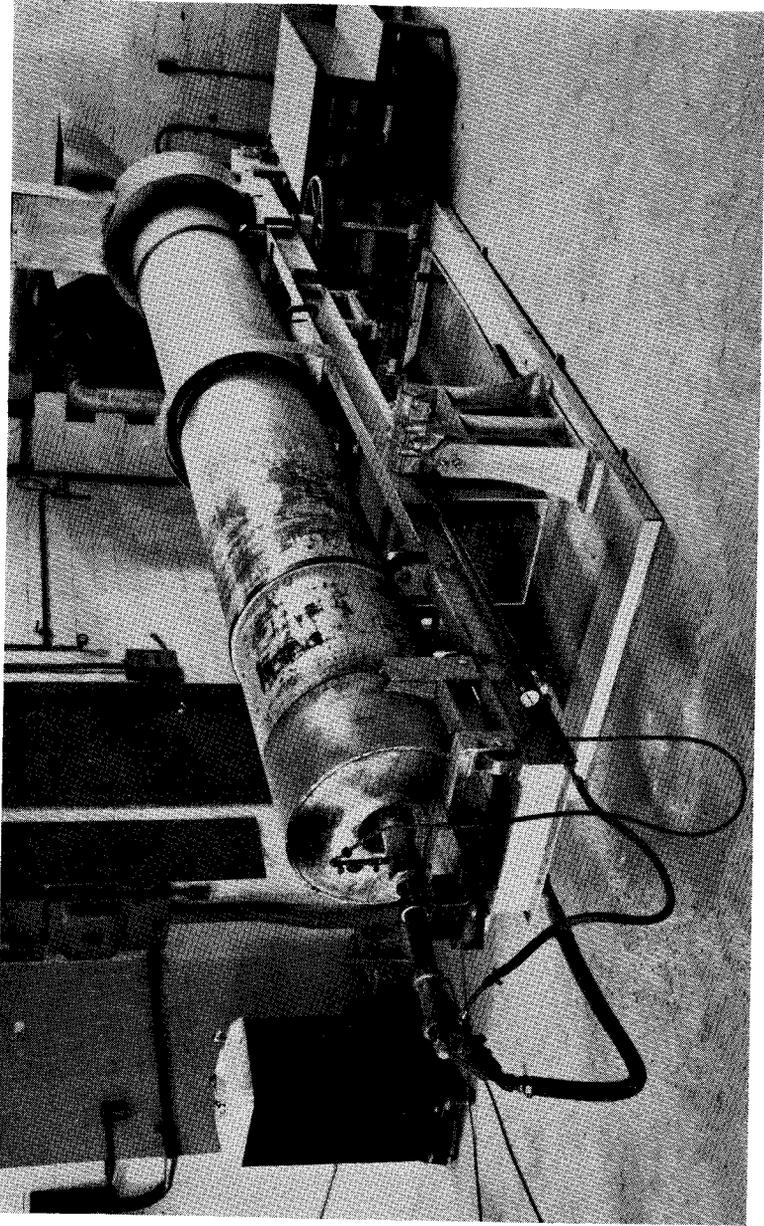
gravity. The most essential test for these clays is the pyrometric cone equivalent test. This test definitely distinguishes refractory clays from non-refractory materials and also indicates the temperature at which the clay can be used.

The criteria given in this report for appraising the refractory clays are largely based on the pyrometric cone equivalent, and the potential use is determined as shown by Table 7.

Table 7.—A.S.T.M. Standard Classification of Fire Clay Refractories (C-27-41)

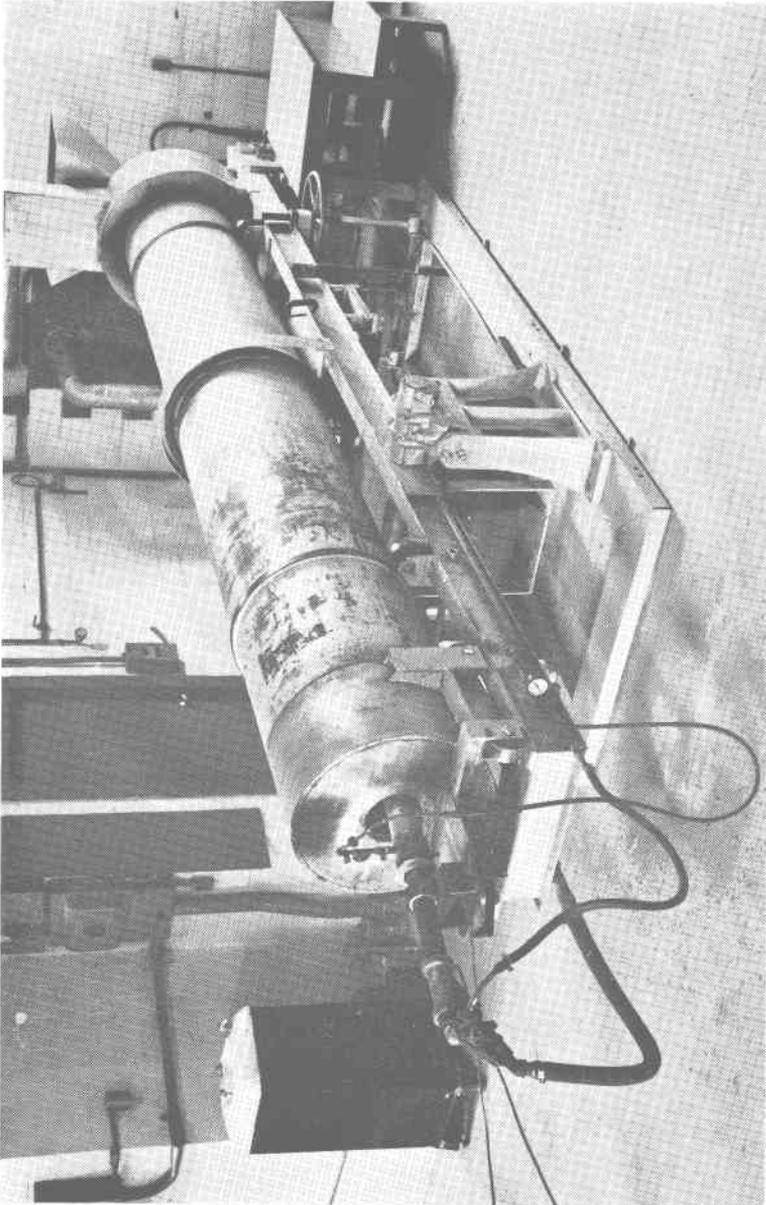
<i>Fire clay brick</i>	<i>Pyrometric cone equivalent</i>
Super duty	Cone 33 and up
High heat duty	Cone 31 - 32
Intermediate heat duty	Cone 29 - 31
Low heat duty	Cone 19 - 29

Plate 1.



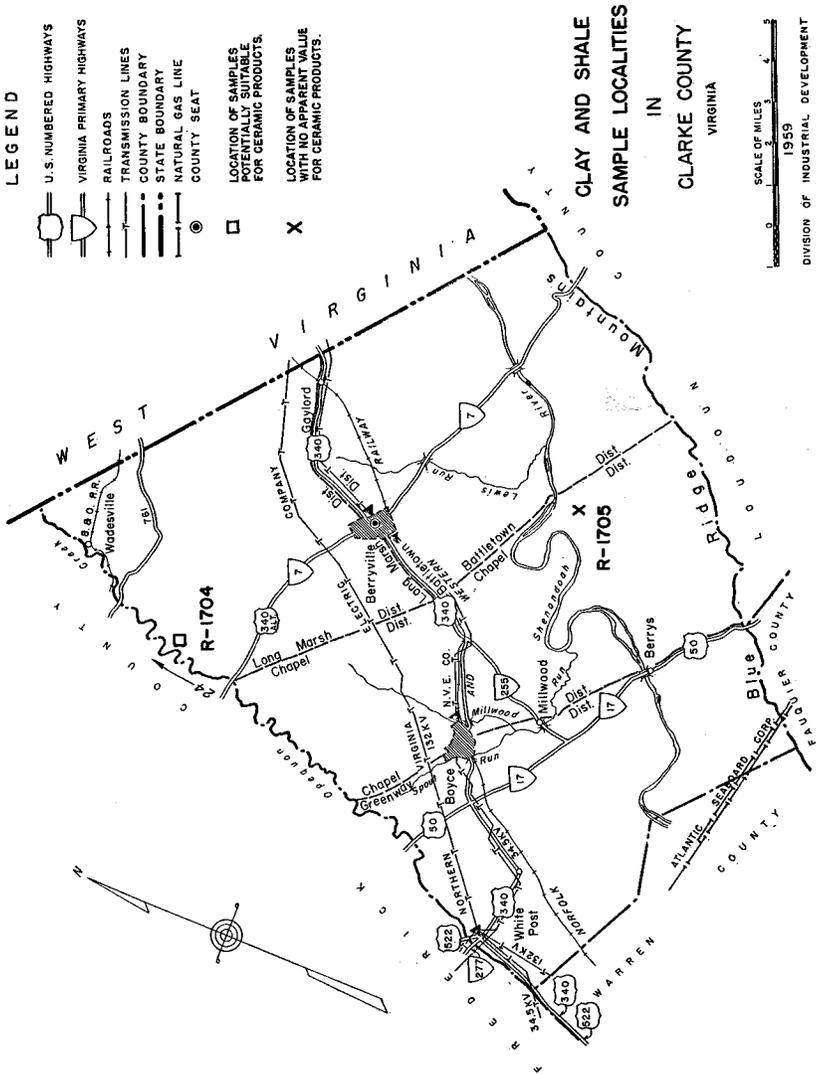
Rotary test kiln used for firing clay materials at the U. S.  
Bureau of Mines laboratory at Norris, Tennessee.

Plate 1.



Rotary test kiln used for firing clay materials at the U. S.  
Bureau of Mines laboratory at Norris, Tennessee.

SAMPLE DESCRIPTIONS  
CHARACTERISTICS  
AND EVALUATIONS



Location Map of Clarke County

## CLARKE COUNTY

Samples were collected in Clarke County from the Martinsburg shale of Ordovician age and from clay of Recent age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-1704	Martinsburg shale	Lightweight aggregate
R-1705	Recent (?) clay	None

SAMPLE: R-1704

County: Clarke

*Locality:* Outcrop on the southwest side of State Road 660 approximately six miles northwest of Berryville and half a mile northwest of the intersection of State Roads 660 and 645.

*Description:* The outcrop consists of approximately 30 feet of dark-gray shale and a few interbedded thin layers of laminated siltstone. The shale weathers to form grayish-orange angular fragments. Well developed fracture cleavage in the outcrop strikes N. 30° E. and dips 60° SE. Some bedding and cleavage planes have been stained rusty brown with iron oxide. The rocks strike N-S to N. 10° E. and dip 25° W. to 30° NW. An overburden of soil up to five feet in thickness is present.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 30 feet of shale and siltstone.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.00

*Raw Properties:* Not too plastic, short and gritty working, requires 17 percent water for plasticity, no drying defects, 2.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red buff	Crumbly soft	3.5	14.2	2.69
2000	Red brown	Very hard	7.0	6.3	2.56
2100	Dk. brown	.....	Expanded	3.5	2.34
2200	Black-brown	.....	Expanded	.....	.....
2300	.....	.....	.....	.....	.....
2400	.....	.....	.....	.....	.....

*Potential Use:* Lightweight aggregate

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>% Abs.</u>	<u>Bulk</u> <u>Sp. Gr.</u>	<u>Lb/ft<sup>3</sup></u>	
1800	5.0	1.99	124.0	No bloating
1900	6.2	1.31	81.6	Slight bloating
2000	6.8	1.05	65.4	Good bloating
2100	7.4	0.67	41.7	Good bloating, slightly sticky
2200	7.4	0.51	31.8	Overbloated, very sticky

*Firing characteristics:* Expanded material has good strength, fairly low absorption, bloating range average.

SAMPLE: R-1705

County: Clarke

*Locality:* Outcrop on the east side of State Road 606 approximately 4½ miles southeast of Berryville and a quarter of a mile north of the intersection of State Roads 606 and 649.

*Description:* An exposure of dark reddish-brown and moderate reddish-brown clay, up to 12 feet in height, was sampled for a distance of 350 feet along the roadcut. The clay weathers to form small angular fragments and contains subangular grains of quartz. Some of the clay contains light-gray mottled zones. The clay is unconformably overlain by intermixed clay and gravel.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of clay from exposure up to 12 feet in height.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 4.90

*Raw Properties:* Not too plastic, short and gritty working, requires 38 percent water for plasticity, no drying defects, 6.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red	Crumbly soft	8.0	23.7	2.88
2000	Dull red	Crumbly soft	11.5	17.9	2.87
2100	Dull dk. red	Crumbly soft	11.5	17.3	2.85
2200	Dk. red-brown	Crumbly soft	12.5	16.6	2.84
2300	Black-brown	Crumbly hard	13.5	14.0	2.81
2400	Blue-black	Very hard	16.0	6.4	2.73

*Bloating Test:* Negative

*Potential Use:* None



## CULPEPER COUNTY

Samples were collected in Culpeper County from shale, mudstone, and clay of Triassic age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-677	Triassic clay	Common brick
R-678	Triassic shale and clay	Could be mixed with other clays to improve plasticity
R-679	Triassic shale and mudstone	Common brick and tile
R-680	Triassic clay	Could be mixed with other clays to improve plasticity

SAMPLE: R-677

County: Culpeper

*Locality:* Outcrop on State Road 620 approximately half a mile south of Kellys Ford.

*Description:* The outcrop, which is exposed for a distance of 210 feet and is seven feet high consists of grayish-red and yellowish-brown clay and a few interbedded thin layers of fine-grained, light-gray and red sandstone. The clay has been formed by the weathering of grayish-red shale of Triassic age. Similar shale and sandstone are exposed in another outcrop several hundred yards to the north.

*Formation or age:* Triassic

*Sampled interval:* Composite sample of clay from outcrop seven feet in height:

*Type:* Clay

*Unfired strength:* Average

*pH:* 4.50

*Raw Properties:* Fairly plastic, smooth and slightly gritty working, requires 33 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Pinkish buff	Crumbly soft	5.5	22.6	2.71
2000	Dk. buff	Crumbly soft	8.5	18.9	2.74
2100	Dull red	Fairly hard	10.0	14.4	2.72
2200	Dk. red brown	Hard	14.5	8.3	2.64
2300	Dk. brown	Very hard	14.5	5.8	2.58
2400	Black brown	Steel hard	15.0	3.2	2.57

*Bloating Test:* Negative

*Potential Use:* Common brick

SAMPLE: R-678

County: Culpeper

*Locality:* Outcrop along the Southern Railway about half a mile north-east of Brandy.

*Description:* An exposure of dark reddish-brown shale and clay, twelve feet in height, extends for 1300 feet along the railroad cut. The shale is cut by veins of light-gray clay. The rocks are overlain by two feet of soil overburden.

*Formation or age:* Triassic

*Sampled interval:* Composite sample of shale and clay from outcrop 12 feet in height.

*Type:* Shale and clay

*Unfired strength:* Above average

*pH:* 4.30

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50 ±	Iron (oxides)	8 ±
Feldspar (some altered)	20 ±	Montmorillonite-chlorite	10 ±
Sericite	5 ±	Heavy minerals	1-2
Kaolin	5 ±		

*Raw Properties:* Plastic and smooth working, requires 29 percent water for plasticity, no drying defects, 5.0 per cent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red buff	Soft crumbly	10.5	19.5	2.68
2000	Lt. red	Fairly hard	13.5	13.3	2.67
2100	Dk. red	Very hard	17.0	5.4	2.65
2200	Dk. red brown	Steel hard	19.0	2.3	2.58
2300	Dk. brown	Steel hard	20.0	2.1	2.55
2400	Dk. brown	.....	18.5	4.7	2.44

*Bloating Test:* Negative

*Potential Use:* Could be mixed with other materials to improve plasticity. Shrinkage is too high for the clay to be used alone.

SAMPLE: R-679

County: Culpeper

*Locality:* Outcrop on State Road 647 about 2½ miles southwest of Lignum.

*Description:* The outcrop, which is exposed for a distance of 735 feet, consists of about 145 feet of light and dark reddish-brown shale and mudstone and interbedded thin layers of fine-grained, dark reddish-brown sandstone. The rocks strike N. 40° to 60° E. and dip 22° to 26° NW. An overburden of soil four feet in thickness is present.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 140 feet of shale and mudstone.

*Type:* Mudstone and shale  
*pH:* 4.90

*Unfired strength:* Low

*Raw Properties:* Short and gritty working, requires 26 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red brown	Crumbly soft	5.0	14.9	2.67
2000	Lt. red	Crumbly soft	5.5	13.7	2.69
2100	Dk. red	Fairly hard	9.0	12.1	2.81
2200	Dk. brown	.....	11.0	1.8	2.55
2300	Dk. brown	.....	5.5	8.8	2.15
2400	Dk. brown	.....	3.5	16.6	2.21

*Bloating Test:* Slight expansion

*Potential Use:* Common brick and tile

SAMPLE: R-680

County: Culpeper

*Locality:* Outcrop on U. S. Highway 29 about 3¼ miles east of Culpeper.*Description:* An exposure of moderate reddish-brown residual clay, seven feet in height, extends for a distance of 430 feet along the roadcut. The clay has been formed by the weathering of shale and mudstone of Triassic age.*Formation or age:* Triassic*Sampled interval:* Sample of clay from outcrop seven feet in height.*Type:* Clay*Unfired strength:* Above average*pH:* 4.1*Raw Properties:* Plastic, smooth working, requires 44 percent water for plasticity, no drying defects, 9.0 percent drying shrinkage.*Fired Properties:*

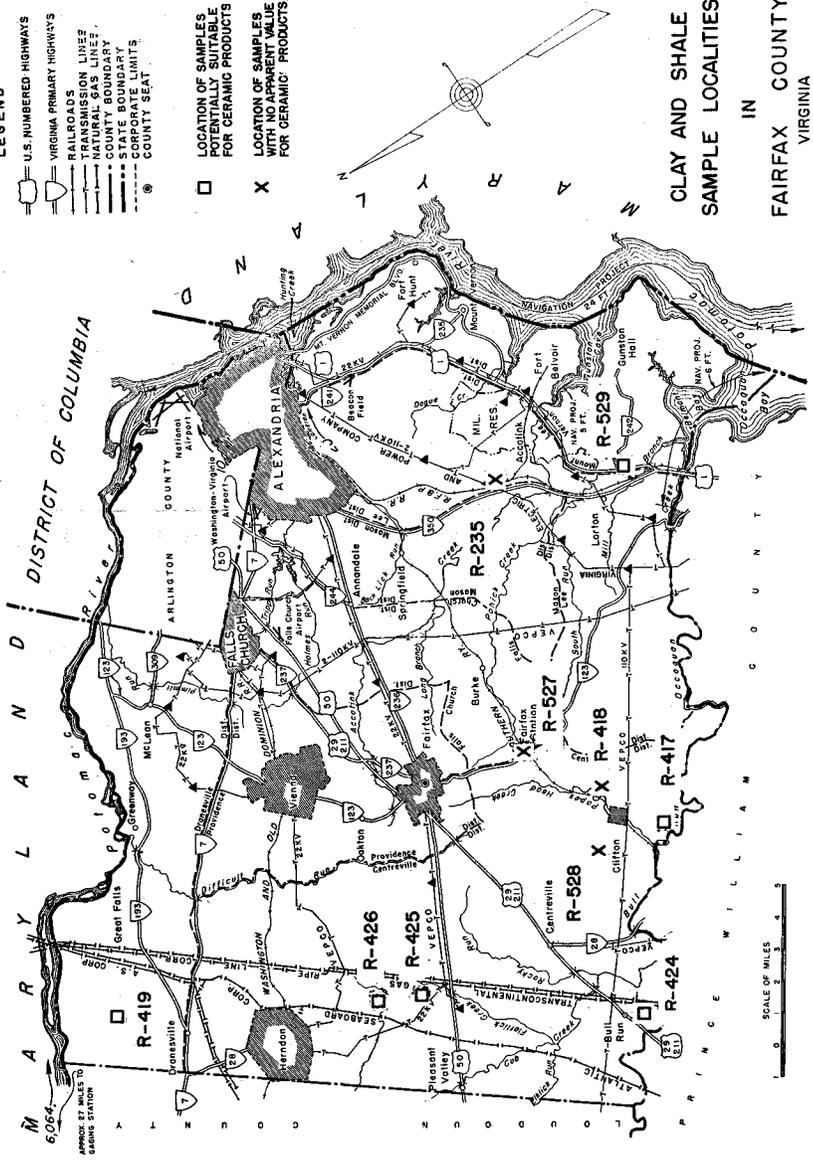
<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Med. red	Crumbly soft	13.0	20.5	2.71
2000	Lt. red buff	Crumbly soft	14.5	18.3	2.87
2100	Dk. red	Very hard	19.5	6.3	2.72
2200	Dk. red brown	Very hard	20.0	4.8	2.75
2300	Dk. brown	Steel hard	22.0	3.3	2.71
2400	Black brown	Steel hard	22.0	2.5	2.72

*Bloating Test:* Negative*Potential Use:* Could be mixed with other materials to improve plasticity.

- LEGEND**
- U.S. NUMBERED HIGHWAYS
  - VIRGINIA PRIMARY HIGHWAYS
  - RAILROADS
  - CONCRETE LINES
  - NATURAL GAS LINES
  - COUNTY BOUNDARY
  - STATE BOUNDARY
  - CORPORATE LIMITS
  - COUNTY SEAT

- LOCATION OF SAMPLES POTENTIALLY SUITABLE FOR CERAMIC PRODUCTS
- X LOCATION OF SAMPLES WITH NO APPARENT VALUE FOR CERAMIC PRODUCTS

CLAY AND SHALE  
SAMPLE LOCALITIES  
IN  
FAIRFAX COUNTY  
VIRGINIA



Location Map of Fairfax County

## FAIRFAX COUNTY

Samples were collected in Fairfax County from schist and phyllite of Precambrian or early Paleozoic age, shale and mudstone of Triassic age, and clay or Cretaceous age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-235	Cretaceous clay	None at present
R-417	Precambrian or early Paleozoic schist	Common brick
R-418	Precambrian or early Paleozoic schist	None at present
R-419	Precambrian or early Paleozoic schist	Common brick
R-424	Triassic shale and mudstone	Common brick
R-425	Triassic shale and mudstone	Brick and tile
R-426	Triassic shale and mudstone	May qualify as brick material with addition of clay
R-527	Precambrian or early Paleozoic phyllite	None at present
R-528	Precambrian or early Paleozoic phyllite	None at present
R-529	Cretaceous clay	Brick and tile

*Sample:* R-235*County:* Fairfax*Locality:* Outcrop on the Richmond, Fredericksburg, and Potomac Railroad about half a mile north of Accotink Station.*Description:* The outcrop consists of seven feet of olive-brown, sandy clay that weathers to form small angular fragments. The clay is covered by seven feet of sandy soil overburden. Clay is exposed in another outcrop 200 feet to the south.*Formation or age:* Cretaceous (?)*Sampled interval:* Sample across seven feet of clay.*Type:* Sandy clay*Unfired strength:* Below average*pH:* 4.75*Raw properties:* Not plastic, slightly sticky, gritty working, requires 43 percent water for plasticity, no drying defects, 10 percent drying shrinkage.*Fired properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	11.5	24.3	2.73
2000	Lt. red buff	Soft crumbly	11.5	21.8	2.73
2100	Red	Soft crumbly	14.0	18.7	2.72
2200	Dk. red	Fairly hard	15.0	16.2	2.72
2300	Dk. red brown	Fairly hard	18.0	11.1	2.69
2400	Black brown	Hard	19.0	7.0	2.66

*Bloating Test:* Negative*Potential Use:* None (fired specimen showed scumming).

SAMPLE: R-417

County: Fairfax

*Locality:* Outcrop along State Road 615 about 1½ miles southwest of Clifton.

*Description:* An exposure of silvery-white mica schist, seven feet in height, extends for a distance of 155 feet along the roadcut. Minor amounts of quartz and garnet occur in the schist. The schistosity strikes north-south and dips 60° E. A joint set, which strikes east-west and dips south, is present.

*Formation or age:* Precambrian or early Paleozoic

*Sampled interval:* Sample of schist from exposure seven feet in height.

*Type:* Mica schist

*Unfired strength:* Low

*pH:* 5.70

*Raw properties:* Not too plastic, short working, requires 28 percent water for plasticity, no drying defects, 3.0 percent drying shrinkage.

*Fired properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Reddish buff	Soft crumbly	3.5	24.2	2.79
2000	Dull red	Fairly hard	4.5	18.4	2.76
2100	Dull brown	Hard	7.0	11.0	2.69
2200	Gray brown	.....	11.0	6.2	2.50
2300	Dk. brown	.....	Expanded	24.8	2.09
2400	.....	.....	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* Common brick

SAMPLE: R-418

County: Fairfax

*Locality:* Small quarry on the north side of State Road 641 approximately one mile east of Clifton.

*Description:* The outcrop consists of about 35 feet of greenish-gray quartz-mica schist exposed in a quarry 20 feet high, 50 feet wide, and 15 feet long. A few lenticular bodies of quartz are associated with the schist. The schistosity strikes N. 25° E. and dips 75° NW. Two joint sets are present in the quarry. One set strikes N. 25° E. and dips 75° NW., and the other set strikes N. 80° E. and dips 40° SE.

*Formation or age:* Precambrian or early Paleozoic

*Sampled interval:* Composite sample across 35 feet of schist.

*Type:* Schist

*Unfired strength:* Low

*pH:* 6.25

*Raw properties:* Not plastic, short and gritty working, requires 22 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	.....	Crumbled	.....	.....	.....
2000	Red brown	Soft crumbly	.....	.....	.....
2100	Red brown	Soft crumbly	0.0	24.1	2.70
2200	Brown	Soft crumbly	4.5	15.2	2.73
2300	Dk. brown	Soft crumbly	10.5	7.6	2.68
2400	Dk. brown	Soft crumbly	10.5	2.6	2.55

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-419

County: Fairfax

*Locality:* Outcrop at the junction of State Roads 603 and 717 about  $2\frac{1}{2}$  miles northeast of Dranesville.

*Description:* An exposure of silvery-white quartz-mica schist, seven feet in height, extends for a distance of 330 feet along State Road 603. A few lenticular bodies of quartz occur in the schist. The schistosity strikes N.  $15^{\circ}$  W. and dips  $60^{\circ}$  to  $65^{\circ}$  NE. The schist is overlain by up to two feet of soil.

*Formation or age:* Precambrian or early Paleozoic

*Sampled interval:* Composite sample of schist from outcrop seven feet in height.

*Type:* Mica schist

*Unfired strength:* Low

*pH:* 5.40

*Raw properties:* Not plastic, short and gritty working, requires 24 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. reddish buff	Soft crumbly	1.5	26.8	2.74
2000	Dull lt. red	Soft crumbly	1.5	23.2	2.73
2100	Dull dk. red	Fairly hard	2.0	16.3	2.70
2200	Dk. red brown	Hard	4.0	11.7	2.64
2300	Dk. brown	.....	7.0	4.8	2.40
2400	Black brown	.....	Expanded	16.4	2.18

*Bloating Test:* Negative

*Potential Use:* Would probably make common brick.

SAMPLE: R-424

County: Fairfax

*Locality:* Outcrop at the junction of State Roads 621 and 658 about three-quarters of a mile south of Bull Run.

*Description:* The outcrop consists of about seven feet of dull-red shale and mudstone and a few interbedded thin layers of cross-bedded sandstone. The rocks strike about N. 20° E. and dip 35° SE.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across six feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Low

*pH:* 6.35

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50 ±	Iron (oxides)	2-3
Feldspar	25 ±	Montmorillonite—chlorite	3-5
Sericite	15-20 ±	Heavy minerals	...
Kaolin	5 ±		

*Raw Properties:* Not plastic, short and gritty working, requires 26 percent water for plasticity, no drying defects, 3.5 per cent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	4.0	22.1	2.75
2000	Dk. buff	Soft crumbly	5.0	18.5	2.71
2100	Red	Fairly hard	10.0	10.8	2.66
2200	Brown	Steel hard	10.0	3.2	2.23
2300	Dk. brown	Steel hard	Expanded	22.9	2.04
2400	Near black	Steel hard	Expanded	30.2	2.05

*Bloating Test:* Negative

*Potential Use:* Low grade common brick.

SAMPLE: R-425

County: Fairfax

*Locality:* Outcrop on State Road 669 about 2½ miles northeast of Chantilly.

*Description:* The outcrop, which is exposed for a distance of 240 feet, consists of 10 feet of dull-red fissile shale and dull-red mudstone, both of which weather to form angular fragments. The rocks strike N. 5° W. and dip 10° NE.

*Formation or age:* Triassic

*Sampled interval:* Sample across 10 feet of shale and mudstone.

*Type:* Shale

*Unfired strength:* Low

*pH:* 8.10

*Raw Properties:* Fairly plastic, short working, requires 21 percent water for plasticity, no drying defects, 2.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Reddish buff	Soft crumbly	4.5	19.2	2.66
2000	Dull med. red	Hard crumbly	6.0	15.7	2.62
2100	Red brown	.....	10.5	3.9	2.48
2200	Dk. brown	.....	Expanded	....	....

*Bloating Test:* Negative

*Potential Use:* Brick and tile

SAMPLE: R-426

County: Fairfax

*Locality:* Outcrop on State Road 608 about 1¼ miles southeast of Floris.*Description:* The outcrop, which is exposed for a distance of 300 feet, consists of 10 feet of dull-red shale and mudstone, both of which weather to form angular fragments. The rocks strike N. 5° W. and dip 25° SW.*Formation or age:* Triassic*Sampled interval:* Sample across 10 feet of shale and mudstone.*Type:* Shale and mudstone*Unfired strength:* Low*pH:* 6.13*Raw Properties:* Not plastic, short and slightly gritty working, requires 29 percent water for plasticity, no drying defects, 2.0 percent drying shrinkage.*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dull med. red	Soft crumbly	3.0	26.1	2.68
2000	Dull red	Soft crumbly	5.0	23.9	2.67
2100	Reddish brown	Hard crumbly	7.5	16.8	2.61
2200	Dk. brown	.....	13.5	2.8	2.02
2300	Dk. brown	.....	Expanded	10.9	1.82
2400	Black brown	.....	Expanded	30.4	1.58

*Bloating Test:* Negative*Potential Use:* May qualify as brick material with the addition of clay.

SAMPLE: R-527

County: Fairfax

*Locality:* Outcrop located at the crossing of State Highway 123 and the Southern Railway.

*Description:* The outcrop consists of approximately 220 feet of weathered silvery-white and yellowish-brown phyllite. A few lenticular bodies of quartz are associated with the phyllite. The cleavage strikes N. 35° E. and dips 75° to 85° NW.

*Formation or age:* Precambrian or early Paleozoic

*Sampled interval:* Composite sample across 220 feet of phyllite.

*Type:* Phyllite

*Unfired strength:* Low

*pH:* 4.95

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	60-70	Kaolin	3-5
Albite	3-5	Montmorillonite	20±
Mica	5±	Iron (OH) <sub>x</sub>	1-2

*Raw Properties:* Fair plasticity, short working, requires 28 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Lt. red	Soft crumbly	0.0	25.8	2.74
2000	Dull red	Soft crumbly	2.5	20.8	2.74
2100	Dull dk. red	Fairly hard	4.5	16.6	2.74
2200	Dk. red brown	Hard	7.0	10.5	2.68
2300	Dk. brown	.....	10.5	1.3	2.26
2400	Black brown	.....	Expanded	17.9	2.28

*Bloating Test:* Negative

*Potential Use:* None (unless mixed with another clay).

SAMPLE: R-528

County: Fairfax

*Locality:* Outcrop along State Road 645 about 1¾ miles north of Clifton.*Description:* An exposure of weathered yellowish-brown phyllite, seven feet in height, extends for a distance of 295 feet along the roadcut. A few small lenticular bodies of white quart occur with the phyllite. The cleavage strikes north-south and the dip varies from 80° W. to vertical. The phyllite is overlain by about one foot of topsoil.*Formation or age:* Precambrian or early Paleozoic*Sampled interval:* Composite sample of phyllite from outcrop seven feet in height.*Type:* Phyllite*Unfired strength:* Low*pH:* 5.20*Raw Properties:* Not plastic, short and gritty working, requires 28 percent water for plasticity, no drying defects, 1.5 percent drying shrinkage.*Fired Properties:*

<u>Temp</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	1.5	32.5	2.69
2000	Lt. reddish buff	Soft crumbly	1.0	27.4	2.72
2100	Dull red	Fairly hard	2.5	21.2	2.68
2200	Dk. red brown	Hard	5.0	15.5	2.66
2300	Dk. brown	Very hard	8.5	5.2	2.54
2400	Black brown	.....	Expanded	10.3	2.26

*Bloating Test:* Negative*Potential Use:* None (unless clay is added).

SAMPLE: R-529

County: Fairfax

*Locality:* Outcrop at the intersection of U. S. Highway 1 and State Highway 242 about 1 $\frac{3}{4}$  miles south of Pohick.

*Description:* An exposure of pale-olive clay, 12 feet in height, extends for a distance of 345 feet along State Highway 242. The clay weathers to form small rectangular fragments, and is overlain by two feet of yellowish loam.

*Formation or age:* Cretaceous (?)

*Sampled interval:* Sample of clay from outcrop 12 feet in height.

*Type:* Clay

*Unfired strength:* Average

*pH:* 5.20

*Raw Properties:* Plastic, smooth and slightly gritty working, requires 36 percent water for plasticity, no drying defects, 8.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	10.5	17.6	2.58
2000	Dull red	Fairly hard	12.5	12.9	2.62
2100	Dull dk. red	Hard	13.5	9.8	2.60
2200	Dk. red brown	Very hard	15.5	6.7	2.53
2300	Dk. brown	.....	Expanded	12.2	2.17
2400	.....	.....	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* Brick and tile (provided increased vitrification can be obtained by longer firing).



## FAUQUIER COUNTY

Samples were collected in Fauquier County from shale and mudstone of Triassic age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential Use</u>
R-242	Triassic shale and siltstone	Brick
R-593	Triassic shale and mudstone	Brick and tile
R-594	Triassic shale and siltstone	Brick and tile
R-595	Triassic shale	Brick and tile
R-596	Triassic shale	Common brick
R-597	Triassic shale and siltstone	Common brick
R-598	Triassic shale and mudstone	Brick and tile

SAMPLE: R-242

County: Fauquier

*Locality:* Outcrop at the junction of State Highway 28 and State Road 661 approximately one mile west of Bealeton.

*Description:* The outcrop consists of about eight feet of dull-red fissile shale and red siltstone. The rocks strike N. 50° E. and dip 20° NW., and are overlain by two feet of soil overburden. A similar shale is exposed in another outcrop 1,000 feet to the northeast.

*Formation or age:* Triassic

*Sampled interval:* Sample across eight feet of shale and siltstone.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.4

*Raw Properties:* Not too plastic, short and gritty working, requires 23 percent water for plasticity, no drying defects, 2.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Red	Soft crumbly	4.0	20.1	2.76
2000	Dk. red	Soft crumbly	5.0	11.5	2.70
2100	Dk. red brown	Very hard	10.5	4.7	2.63
2200	Dk. brown	Steel hard	Expanded	.....	2.28
2300	Dk. brown	Steel hard	Expanded	.....	.....

*Bloating Test:* Negative

*Potential Use:* Brick

*Extruded Bars (1/2"):*

*Extrusion characteristics:* Poor

	Unfired	Fired
Transverse strength psi:	120.0	1275

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

App. Sp. Gr.	2.60	% Shrinkage	4.0
% Absorption	9.0		

SAMPLE: R-593

County: Fauquier

*Locality:* Outcrop on State Road 652 about one mile east of Greenville.*Description:* The outcrop consists of two layers of interbedded reddish brown mudstone that total 15 feet in thickness, separated by a five foot layer of medium-bedded, fine-grained sandstone. These beds strike N. 25° E. and dip 30° NW. and are overlain by two feet of soil.*Formation or age:* Triassic*Sampled interval:* Composite sample across 15 feet of shale and mudstone.*Type:* Shale and mudstone*Unfired strength:* Average*pH:* 6.9*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	50 ±	Iron (oxides)	5-8
Feldspar	20 ±	Montmorillonite-chlorite	5-8
Sericite	10 ±	Heavy minerals	2-3
Kaolin	10 ±		

*Raw Properties:* Fairly plastic and smooth working, requires 26.0 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.*Bloating Test:* Negative*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	5.0	23.4	2.72
2000	Lt. red brown	Hard	8.0	14.5	2.67
2100	Red brown	Steel hard	11.0	7.8	2.55
2200	Very dk. brown	Steel hard	11.0	4.8	2.39
2300	Near black	Steel hard	Expanded	.....	2.22
2400	Near black	Steel hard	Expanded	.....	2.05

*Potential Use:* Brick and tile

Miniature brick (pressed at 5,000 psi., and fired to 1900° F with one hour soak):

Approx. Sp. Gr.	2.67	% Shrinkage	4.0
% Absorption	6.1	Hardness	Steel hard

SAMPLE: R-594 County: Fauquier

Locality: Outcrop on State Road 667, about three miles northwest of Catlett.

Description: The outcrop consists of 60 feet of reddish-brown shale and siltstone, both of which weather to form angular fragments. The rocks strike N. 40° E. and dip 25° NW. and have two feet of overburden.

Formation or age: Triassic

Sampled interval: Sample across 60 feet of shale and siltstone.

Type: Shale Unfired strength: Average  
pH: 5.70

Raw Properties: Fairly plastic and smooth working, requires 28.0 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

**Fired Properties:**

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	6.0	22.4	2.70
2000	Lt. red brown	Very hard	7.0	13.3	2.66
2100	Red brown	Steel hard	8.5	12.5	2.72
2200	Brown	Steel hard	14.0	6.4	2.50
2300	Dk. brown	Steel hard	14.0	4.0	2.43
2400	Near black	Steel hard	Expanded		2.30

Bloating Test: Negative

Potential Use: Brick and tile

SAMPLE: R-595 County: Fauquier

Locality: Outcrop on State Road 610, just southeast of Elkrun.

Description: The outcrop consists of about 195 feet of reddish-brown and greenish-yellow micaceous shale and interbedded layers of yellowish-brown and reddish-brown siltstone. The rocks strike N. 60° to 75° E. and dip 17° to 22° NW. An overburden of soil up to seven feet in thickness is present.

Formation or age: Triassic

Sampled interval: Composite sample across 180 feet of shale.

Type: Shale Unfired strength: Average

pH: 5.90

Raw Properties: Fairly plastic and smooth working, requires 27.0 per cent water for plasticity.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. orange buff	Soft crumbly	5.0	23.0	2.67
2000	Lt. red brown	Hard	7.5	19.7	2.63
2100	Red brown	Very hard	10.0	10.3	2.59
2200	Brown	Steel hard	12.0	6.5	2.52
2300	Dk. brown	Steel hard	12.5	3.8	2.43
2400	Near black	Steel hard	Expanded	3.6	2.19

Bloating Test: Negative

Potential Use: Brick and tile (Plate 9)

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

Approx. Sp. Gr.	2.68	% Shrinkage	3.4
% Absorption	7.0	Hardness	Very hard

SAMPLE: R-596

County: Fauquier

*Locality:* Outcrop on State Road 805 about 1¼ miles northeast of Bealeton.

*Description:* The outcrop consists of 30 feet of reddish-brown shale which weathers to form angular fragments. The rocks strike N. 20° E and dip 15° NW.

*Formation or age:* Triassic

*Sampled interval:* Sample across 30 feet of shale.

*Type:* Shale

*Unfired strength:* Average

*pH:* 8.2

*Raw Properties:* Fairly plastic, smooth working, requires 27.0 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. orange buff	Fairly hard	6.0	12.6	2.65
2000	Brown	Steel hard	Expanded	3.3	2.17
2100	.....	.....	Expanded	.....	.....
2200	.....	.....	Expanded	.....	.....
2300	.....	.....	Expanded	.....	.....
2400	.....	.....	Expanded	.....	.....

*Bloating Test:* Negative

*Potential Use:* Probably would make common brick at 1900° F.

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

Approx. Sp. Gr.	2.64	% Shrinkage	2.6
% Absorption	5.0	Hardness	Steel hard

SAMPLE: R-597

County: Fauquier

*Locality:* Outcrop on State Road 610 about half a mile east of Midland.*Description:* The outcrop consists of about 30 feet of olive-gray and reddish-brown shale, reddish-brown siltstone, and a layer of fine-grained sandstone. Some of the siltstone beds are laminated and show cross-bedding. The rocks strike N. 80° E. and dip 10° NW., and are overlain by up to six feet of soil overburden.*Formation or age:* Triassic*Sampled interval:* Composite sample across 28 feet of shale and siltstone.*Type:* Shale*Unfired strength:* Low*pH:* 8.3*Raw Properties:* Not too plastic, short working, requires 23.0 percent water for plasticity, no drying defects, 2.5 percent drying shrinkage.*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	2.5	18.2	2.49
2000	Red brown	Fairly hard	5.0	12.6	2.38
2100	Brown	Steel hard	12.5	0.9	2.20
2200	.....	(Melted)	.....	.....	.....

*Bloating Test:* Negative*Potential Use:* Probably would make common brick at 2050°F. (color poor vitrification, range short).

SAMPLE: R-598 *County:* Fauquier

*Locality:* Outcrop on State Road 657 about 1¼ miles north of Remington.

*Description:* The outcrop, which is exposed for a distance of 165 feet, consists of about eight feet of weathered reddish-brown micaceous shale and mudstone. The rocks strike N. 25° to 35° E. and dip 12° NW. An overburden of soil one foot in thickness is present.

*Formation or age:* Triassic

*Sampled interval:* Sample across eight feet of shale and mudstone.

*Type:* Shale and mudstone *Unfired strength:* Above average

*pH:* 5.9

*Raw Properties:* Plastic, smooth working, requires 30 percent water for plasticity, no drying defects 5.0 percent drying shrinkage.

*Fired Properties:*

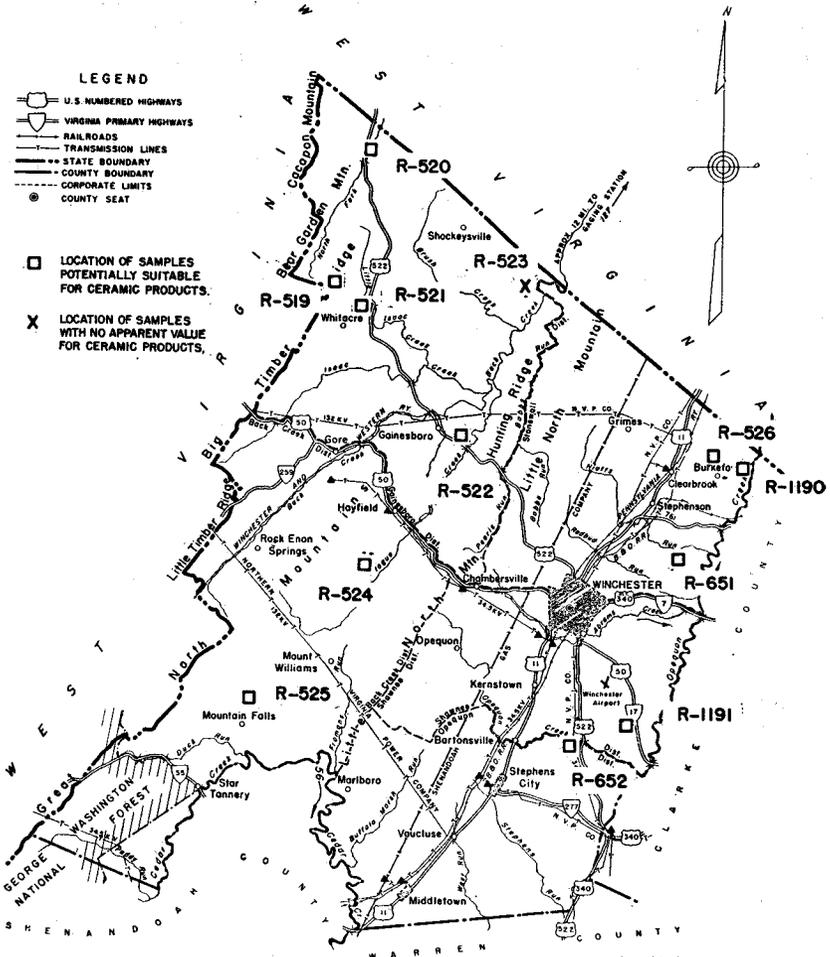
Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. orange buff	Soft crumbly	6.0	16.1	2.77
2000	Dk. orange buff	Fairly hard	7.5	16.0	2.71
2100	Brown red	Very hard	11.0	13.5	2.67
2200	Brown red	Steel hard	11.0	10.5	2.65
2300	Dk. brown	Steel hard	14.0	1.1	2.40
2400	Near black	Steel hard	14.0	1.6	2.40

*Bloating Test:* Negative

*Potential Use:* Brick and tile

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

Approx. Sp. Gr.	2.61	% Shrinkage	8.9
% Absorption	1.4	Hardness	Steel hard



CLAY AND SHALE  
SAMPLE LOCALITIES

IN  
FREDERICK COUNTY  
VIRGINIA

Location Map of Frederick County

## FREDERICK COUNTY

Samples were collected in Frederick County from the Marcellus shale, Hamilton formation, Brallier shale, and Chemung formation of Devonian age, and from the Martinsburg shale of Ordovician age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential Use</u>
R-519	Chemung shale	Brick and quarry tile
R-520	Hamilton shale	Common brick and quarry tile
R-521	Chemung shale and siltstone	Common brick and quarry tile
R-522	Hamilton shale	Common brick and quarry tile
R-523	Brallier shale and siltstone	None at present
R-524	Marcellus shale	Common brick and quarry tile
R-525	Devonian shale and siltstone	Common brick and quarry tile
R-526	Martinsburg shale	Common brick and quarry tile
R-651	Martinsburg shale and mudstone	Common brick and tile
R-652A	Unweathered Martinsburg shale	Brick, tile, and lightweight aggregate
R-652B	Weathered Martinsburg shale	Brick, tile, and lightweight aggregate
R-1190A	Unweathered Martinsburg shale	Lightweight aggregate
R-1190B	Weathered Martinsburg shale	Brick and tile
R-1191A	Unweathered Martinsburg shale	Common brick and lightweight aggregate
R-1191B	Weathered Martinsburg shale	Common brick

SAMPLE: R-519

County: Frederick

*Locality:* Outcrop at the junction of State Roads 696 and 698 about 1½ miles north of Whitacre P. O.

*Description:* The outcrop consists of 250 feet of olive-brown fissile shale and interbedded thin layers of fine- to medium-grained, light brownish-gray sandstone. The shale weathers to form light-brown and light-green angular fragments, and the sandstone weathers to form angular blocks. The rocks strike N. 35° E. and dip 35° to 59° SE., and are covered by up to two feet of overburden.

*Formation or age:* Chemung formation

*Sampled interval:* Composite sample across 240 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.20

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	60 ±	Kaolin	15-20
Feldspar	2-3	Iron (oxides)	2-3
Sericite	10 ±	Montmorillonite-chlorite	3-5

*Raw Properties:* Not plastic, short working, requires 21 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Orange buff	Soft crumbly	5.0	15.6	2.68
2000	Dk. buff	Soft crumbly	5.0	12.9	2.66
2100	Lt. brown	Hard	6.5	12.1	2.64
2200	Dk. red brown	Steel hard	10.0	11.5	2.56
2300	Dk. brown	Steel hard	Expanded	3.6	2.51
2400	Near black	Steel hard	Expanded	4.8	2.22

*Bloating Test:* Negative

*Potential Use:* Common brick at about 2150°F.; probably quarry tile.

SAMPLE: R-520

County: Frederick

*Locality:* Outcrop on the east side of U. S. Highway 522 about one mile south of the West Virginia State Line.

*Description:* The outcrop consists of 140 feet of olive-brown and dark-gray shale which weathers to form light-brown angular fragments. The rocks strike N. 30° E. and dip 39° SE., and have one foot of overburden.

*Formation or age:* Hamilton formation

*Sampled interval:* Sample across 140 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.0

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	50 ±	Kaolin	8-10
Feldspar	1-2	Iron (oxides)	3-5
Sericite	20-25	Montmorillonite-chlorite	5 ±

*Raw Properties:* Not plastic, short and gritty working, requires 19 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

#### *Fired Properties*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	4.5	15.1	2.65
2000	Orange buff	Soft crumbly	6.0	11.5	2.62
2100	Lt. brown	Very hard	7.5	8.6	2.59
2200	Dk. red brown	Steel hard	9.5	7.0	2.64
2300	Dk. brown	Steel hard	14.0	1.5	2.33
2400	Near black	Steel hard	Expanded	0.8	1.92

*Bloating Test:* Negative

*Potential Use:* Common brick at about 2150° F., probably quarry tile.



A. Outcrop of the Chemung formation (Sample R-521) at the junction of U. S. Highway 522 and State Road 698 about 1½ miles northwest of Cross Junction P. O., Frederick County.



B. Outcrop of the Martinsburg shale (Sample R-652) on the west side of U. S. Highway 522, just south of Parkins Mill, Frederick County.



A. Outcrop of the Chemung formation (Sample R-521) at the junction of U. S. Highway 522 and State Road 698 about  $1\frac{1}{2}$  miles northwest of Cross Junction P. O., Frederick County.



B. Outcrop of the Martinsburg shale (Sample R-652) on the west side of U. S. Highway 522, just south of Parkins Mill, Frederick County.

SAMPLE: R-521

County: Frederick

*Locality:* Outcrop at the junction of U. S. Highway 522 and State Road 698 about 1½ miles northwest of Cross Junction P. O. (Plate 2A).

*Description:* The outcrop, which is exposed for a distance of 1290 feet along U. S. Highway 522, consists of about 140 feet of dark yellowish-brown and olive-gray micaceous shale, brownish-gray siltstone, and interbedded thin layers of fine-grained sandstone. At the southern end of the roadcut a greenish shale, which weathers to form peg-shaped fragments, is exposed above these beds. The rocks strike N. 25° E. and dip 60° to 65° SE. An overburden of soil six feet in thickness is present.

*Formation or age:* Chemung formation.

*Sampled interval:* Composite sample across 130 feet of shale and siltstone.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.5

*Raw Properties:* Not plastic, short and gritty working, requires 18 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Orange buff	Soft crumbly	5.0	14.0	2.67
2000	Orange buff	Soft crumbly	5.0	12.2	2.66
2100	Lt. brown	Hard	6.0	10.2	2.67
2200	Dk. red brown	Steel hard	7.0	7.6	2.59
2300	Dk. brown	Steel hard	9.0	5.0	2.52
2400	Near black	Steel hard	Expanded	5.3	2.28

*Bloating Test:* Negative

*Potential Use:* Common brick at about 2150° F, probably quarry tile.

SAMPLE: R-522

County: Frederick

*Locality:* Outcrop at the intersection of U. S. Highway 522 and State Road 681 about three miles northwest of Nain.

*Description:* The outcrop consists of 60 feet of olive-brown and olive-gray shale which weathers to form small light-brown and rusty-brown peg-shaped fragments. The rocks strike N. 15° E. and dip 35° SE., and are overlain by two feet of soil.

*Formation or age:* Hamilton formation

*Sampled interval:* Sample across 60 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.9

*Raw Properties:* Not plastic, short and gritty working, requires 18 per cent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Orange buff	Soft crumbly	4.5	13.0	2.51
2000	Orange buff	Soft crumbly	5.0	9.9	2.50
2100	Lt. brown	Hard	8.5	6.7	2.46
2200	Dk. red brown	Steel hard	10.0	7.1	2.59
2300	Dk. brown	Steel hard	10.0	5.6	2.54
2400	.....	(Melted)	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* Common brick at about 2150° F, probably quarry tile.

SAMPLE: R-523

County: Frederick

*Locality:* Outcrop on the north side of State Road 671 about three quarters of a mile west of Dehaven.

*Description:* The outcrop consists of 230 feet of grayish-olive fissile shale and grayish-olive micaceous siltstone with interbedded layers of fine-grained, reddish-brown sandstone. The rocks strike N. 30° E. and dip generally 75° SE.

*Formation or age:* Brallier shale

*Sampled interval:* Composite sample across 230 feet of shale and siltstone.

*Type:* Shale

*Unfired strength:* Very low

*pH:* 6.8

*Raw Properties:* Not plastic, short and very sandy working, requires 16 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Soft crumbly	0.5	9.2	2.45
2000	Buff	Soft crumbly	1.5	5.8	2.44
2100	Red brown	Hard	4.5	4.9	2.41
2200	Red brown	Very hard	5.5	2.5	2.47
2300	Near black	Steel hard	5.5	0.3	2.36
2400	Near black	Steel hard	5.5	.....	2.22

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-524

County: Frederick

*Locality:* Outcrop on the east side of State Road 600 about  $2\frac{1}{4}$  miles southwest of Hayfield P. O.

*Description:* An exposure of dark-gray fissile shale, 10 feet in height, extends for a distance of 730 feet along the roadcut. The shale weathers to form small peg-shaped fragments, and appears to strike northwest and dip southwest.

*Formation or age:* Marcellus shale

*Sampled interval:* Sample of shale from outcrop 10 feet in height.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.4

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50 ±	Kaolin	15-20 ±
Feldspar	3-5	Iron (oxides)	2-3
Sericite	15-20 ±	Montmorillonite-chlorite	1-2

*Raw Properties:* Not plastic, short and gritty working, requires 17 percent water for plasticity, no drying defects, 3.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	4.0	18.7	2.56
2000	Orange buff	Soft crumbly	5.0	10.3	2.50
2100	Lt. brown	Hard	7.0	10.0	2.53
2200	Dk. red brown	Steel hard	7.0	8.4	2.50
2300	Dk. brown	Steel hard	6.0	7.2	2.31
2400	.....	(Melted)	Expanded	.....	1.83

*Bloating Test:* Negative

*Potential Use:* Common brick and probably quarry tile.

SAMPLE: R-525

County: Frederick

*Locality:* Outcrop on the east side of State Road 600 about three-quarters of a mile northeast of Mountain Falls.

*Description:* The outcrop consists of about five feet of light-blue, olive-brown and light olive-gray shale, and medium-gray and olive-gray laminated siltstone. The siltstone, which is exposed at the southwestern end of the cut, weathers to form small rectangular blocks.

*Formation or age:* Devonian

*Sampled interval:* Sample across five feet of shale and siltstone.

*Type:* Shale and siltstone

*Unfired strength:* Low

*pH:* 5.6

*Raw Properties:* Not plastic, short working, requires 20 percent water for plasticity, no drying defects, 4.5 per cent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Salmon buff	Soft crumbly	5.0	17.0	2.72
2000	Salmon buff	Soft crumbly	5.0	13.1	2.69
2100	Medium brown	Steel hard	10.0	7.3	2.63
2200	Dk. brown	Steel hard	10.5	4.7	2.60
2300	Black	Steel hard	10.5	2.2	2.54
2400	Black	Steel hard	Expanded	0.6	2.23

*Bloating Test:* Negative

*Potential Use:* Common brick and probably quarry tile.

SAMPLE: R-526

County: Frederick

*Locality:* Outcrop at the junction of State Roads 667 and 668 about two miles northeast of Clearbrook P. O.

*Description:* The outcrop consists of 185 feet of weathered yellowish-orange shale. The rocks strike N. 55° E. and dip 30° SE., and are overlain by one foot of soil.

*Formation or age:* Martinsburg shale

*Sampled interval:* Sample across 185 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.0

*Raw Properties:* Fair plasticity, short and gritty working, requires 25 percent water for plasticity.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	4.5	18.8	2.70
2000	Orange buff	Fairly hard	5.0	13.6	2.68
2100	Med. brown	Steel hard	8.0	7.1	2.61
2200	Dk. red brown	Steel hard	10.0	4.7	2.57
2300	Dk. brown	Steel hard	13.5	2.1	2.50
2400	Near black	Steel hard	Expanded	0.8	2.24

*Bloating Test:* Negative

*Potential Use:* Common brick and probably quarry tile.

SAMPLE: R-651

County: Frederick

*Locality:* Outcrop at the junction of State Roads 660 and 664 approximately  $2\frac{1}{2}$  miles southeast of Stephenson P. O.

*Description:* The outcrop, which is exposed for a distance of 405 feet, consists of about 250 feet of weathered pale yellowish-orange and dark yellowish-orange shale and mudstone, and interbedded thin layers of fine-grained, moderate yellowish-orange sandstone. The rocks strike N.  $25^{\circ}$  E. and dip  $65^{\circ}$  to  $75^{\circ}$  SE., and are overlain by about one foot of soil.

*Formation or age:* Martinsburg shale.

*Sampled interval:* Composite sample across 245 feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Low

*pH:* 5.60

*Raw Properties:* Not too plastic, slightly short working, requires 28 percent water for plasticity, no drying defects, 3.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Soft crumbly	6.0	18.9	2.70
2000	Lt. red	Fairly hard	8.5	11.7	2.64
2100	Dk. red	Very hard	11.5	4.4	2.54
2200	Dk. red brown	Steel hard	14.0	0.9	2.42
2300	Dk. brown	.....	Expanded	6.1	2.23
2400	Brownish black	.....	Expanded	20.6	1.95

*Bloating Test:* Negative

*Potential Use:* Common brick and tile

SAMPLE: R-652A      *County:* Frederick

*Locality:* Outcrop on the west side of U. S. Highway 522, just south of Parkins Mill. (Plate 2B)

*Description:* The outcrop which is exposed for 300 feet, consists of 32 feet of dark-gray and olive-gray shale and interbedded layers of fine to medium-grained, olive-gray, laminated sandstone. The rocks strike N. 25° E. and dip 44° SE. The beds are weathered to a depth of about ten feet and are overlain by one foot of soil.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 30 feet of unweathered shale.

*Type:* Unweathered Shale      *Unfired strength:* Very low

*pH:* 6.9

*Composition:*

<i>X-ray and Petrographic Analysis</i>		<i>Spectrographic Analysis</i>	
	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	60-70	K <sub>2</sub> O	3.75
Sericite	5-8	CaO	0.4
Kaolin	10-15	TiO <sub>2</sub>	1.0
Chlorite	.....	Mn	0.5
Montmorillonite	3-5	Fe <sub>2</sub> O <sub>3</sub>	5.0
Iron (oxides)	2-3		

*Raw Properties:* Short working, slightly gritty, requires 18 percent water for plasticity, no drying defects, no drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	1.0	15.4	2.65
2000	Med. red	Very hard	2.5	9.0	2.59
2100	Dk. red brown	Steel hard	5.0	4.4	2.15
2200	Med. brown	.....	Expanded	.....	.....
2300	Med. brown	.....	Expanded	.....	.....
2400	Med. brown	.....	Expanded	.....	.....

*Potential Use:* Brick, tile and lightweight aggregate. (Plate 4, Figure 2)

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>% Abs.</u>	<u>Bulk</u> <u>Sp. Gr.</u>	<u>Lb/ft<sup>3</sup></u>	<u>Remarks</u>
1800	4.6	2.03	126.4	No bloating
1900	6.4	1.39	86.6	Slight bloating
2000	6.6	1.10	68.5	Good bloating
2100	10.1	0.54	33.6	Overbloomed, slightly sticky
2200	11.5	0.51	31.7	Overbloomed, very sticky
2300	15.9	0.44	27.4	Overbloomed, beginning to slag

*Rotary Kiln Tests:*

## Screen Analysis of Unfired Material:

<u>Sieve size</u>	<u>Percent retained</u>
-1/2" +3/8"	7.4
-3/8" +4 mesh	55.2
-4 mesh +8 mesh	15.8
-8 mesh +20 mesh	11.8
-20 mesh (passing)	9.9
Total	100.1

Crushing characteristics: Good

Retention time in kiln: 13.0 minutes

Time in heat zone: 6.0 minutes

Maximum temp. °F.: 2020

Minimum temp. °F.: 1925

Best bloating temp. °F.: 1975

Processing characteristics: Very good

ASTM container method:

Weight of unfired shale Lb/ft<sup>3</sup>: 87.9Weight of fired shale Lb/ft<sup>3</sup>: 40.0

Suspended weight method:

Weight of fired shale: 57.3 pounds

Percent absorption: 7.6

Color of aggregate: Red brown

Aggregate strength: Excellent

## Screen Analysis of Fired Material:

Crushed to pass 3/8" sieve (ASTM specifications for lightweight aggregate used in concrete blocks)

<u>Sieve size</u>	<u>Percent retained</u>
-3/8" +4 mesh	33.1
-4 mesh +8 mesh	43.9
-8 mesh +20 mesh	15.7
-20 mesh +65 mesh	4.2
-65 mesh (passing)	3.2
Total	100.1

SAMPLE: R-652B

*Sampled interval:* Sample of 10 feet of weathered shale from Locality R-652A

*Type:* Weathered Shale

*Unfired strength:* Low

*pH:* 6.00

*Raw Properties:* Fair plasticity, slightly short and gritty working, requires 26 percent water for plasticity, no drying defects, 4.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red	Crumbly soft	5.5	16.1	2.68
2000	Red	Hard	10.0	8.5	2.63
2100	Dk. brown	Steel hard	13.5	2.7	2.53
2200	Dk. brown	Sl. glazed	13.0	1.8	2.15
2300	Dk. brown	.....	Expanded	14.4	2.05
2400	Brownish black	.....	Expanded	24.0	1.83

*Potential Use:* Common brick, tile, and lightweight aggregate.

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>% Abs.</u>	<u>Bulk</u> <u>Sp. Gr.</u>	<u>Lb/ft<sup>3</sup></u>	<u>Remarks</u>
1900	10.0	1.72	71.6	No bloating
2000	6.1	1.45	90.3	No bloating
2100	2.9	1.25	77.9	Good bloating
2200	3.0	0.70	43.6	Overbloating, sticky and fragile

The expanded aggregate has low absorption, good strength and the bloating range is satisfactory.

*Chemical Analyses: Unweathered and Weathered Martinsburg Shale*

<u>Percent</u>	(R-652-A) <u>Unweathered shale</u>	(R-652-B) <u>Weathered shale</u>
SiO <sub>2</sub>	60.26	63.53
Al <sub>2</sub> O <sub>3</sub>	16.05	15.42
TiO <sub>2</sub>	0.96	1.08
FeO	3.00	1.53
Fe <sub>2</sub> O <sub>3</sub>	6.21	5.89
CaO	0.38	0.33
MgO	2.60	1.87
Na <sub>2</sub> O	0.87	0.93
K <sub>2</sub> O	4.47	3.96
MnO	0.06	0.10
S	0.0	0.0
P <sub>2</sub> O <sub>5</sub>	0.16	0.16
C	0.36	0.21
Ig. loss	5.60	5.64
Total	<u>100.62</u>	<u>100.62</u>

SAMPLE: R-1190A County: Frederick

*Locality:* Outcrop on the northeast side of State Road 668 about 1½ miles northwest of the Frederick-Clarke County Line.

*Description:* The outcrop, which is exposed for a distance of 600 feet, consists of 200 feet of olive-gray shale and interbedded layers of fine-grained, gray siltstone. The shale weathers to form grayish-orange angular and peg-shaped fragments. The rocks strike N. 15° E. and dip 70° to 80° NW. The beds are weathered to a depth of about seven feet, and are overlain by up to three feet of overburden.

*Formation or age:* Martinsburg Shale.

*Sampled interval:* Composite sample across 200 feet of unweathered shale and siltstone.

*Type:* Unweathered shale

*Unfired strength:* Low

*pH:* 7.79

*Raw Properties:* Not plastic, short working, requires 20 percent water for plasticity, no drying defects, 3.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Soft crumbly	4.0	14.6	2.59
2000	Red	Fairly hard	5.5	6.5	2.42
2100	Dk. red brown	Hard	5.5	5.8	2.48
2200	Dk. brown	.....	5.5	0.7	2.11
2300	Dk. brown	.....	Expanded	1.8	1.70
2400	Dk. brown	.....	Expanded	1.2	1.78

*Potential Use:* Lightweight aggregate

*Bloating Test:*

Temp ° F.	% Abs.	Bulk Sp. Gr.	Lb/ft <sup>3</sup>	Remarks
1900	8.2	1.70	105.9	No bloating
2000	7.9	1.45	90.3	Slight bloating
2100	5.8	0.96	59.8	Good expansion
2200	9.8	0.64	39.9	Overbloated and sticky
2300	7.9	0.56	34.9	Overbloated and sticky

*Firing Characteristics:* Good aggregate material, bloating range rather short.

SAMPLE: R-1190B

*Sampled interval:* Seven feet of weathered shale and siltstone from locality R-1190A.

*Type:* Weathered shale                      *Unfired strength:* Low

*pH:* 7.20

*Raw Properties:* Fairly plastic, smooth working, requires 24 percent water for plasticity, no drying defects, 3.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	3.5	19.5	2.43
2000	Lt. red	Fairly hard	5.0	13.1	2.39
2100	Dk. red	Very hard	10.0	5.6	2.33
2200	Dk. red brown	Steel hard	12.5	2.6	2.25
2300	Dk. brown	.....	Expanded	2.2	2.08
2400	Very dk. brown	.....	Expanded	4.9	2.02

*Bloating Test:* Fair (not adequate for aggregate).

*Potential Use:* Brick and tile

SAMPLE: R-1191A County: Frederick

*Locality:* Outcrop on the west side of U. S. Highway 50 approximately four miles southeast of Winchester.

*Description:* The outcrop consists of about 90 feet of dark-gray micaceous siltstone and olive-gray and dark-gray shale. Some of the siltstone is laminated and crossbedded. The rocks strike N. 20° E. and dip 50° to 65° SE. The beds are weathered to a depth of about six feet, and are overlain by one foot of soil.

*Formation or age:* Martinsburg shale

*Sampled interval:* Sample across 90 feet of shale and siltstone.

*Type:* Unweathered shale                      *Unfired strength:* Low  
*pH:* 8.00

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50-60	Calcite (carbonates)	2-3
Kaolin	25-30	Montmorillonite	5-8
Sericite	10±	Illite	less than 3
Iron (oxides)	6-8±		

*Raw Properties:* Not plastic, short working, requires 17 percent water for plasticity, no drying defects, 3.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Brownish tan	Soft crumbly	4.5	14.0	2.70
2000	Dull red	Fairly hard	5.0	9.0	2.61
2100	Dk. red brown	Hard	6.5	6.9	2.36
2200	Dk. brown	.....	Expanded	35.7	1.38

*Potential Use:* Might make common brick; excellent lightweight aggregate material.

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>% Abs.</u>	<u>Bulk</u> <u>Sp. Gr.</u>	<u>Lb/ft<sup>3</sup></u>	<u>Remarks</u>
1900	6.5	1.66	103.4	No bloating
2000	4.6	1.12	69.8	Fair bloating
2100	7.4	0.85	53.0	Excellent bloating
2200	10.1	0.50	31.2	Overbloating and very sticky

*Firing characteristics:* Expansion very uniform, percent absorption low, strength of expanded particles very good.

SAMPLE: R-1191B

*Sampled interval:* Six feet of weathered shale from locality R-1191A.

*Type:* Weathered shale

*Unfired strength:* Low

*pH:* 6.73

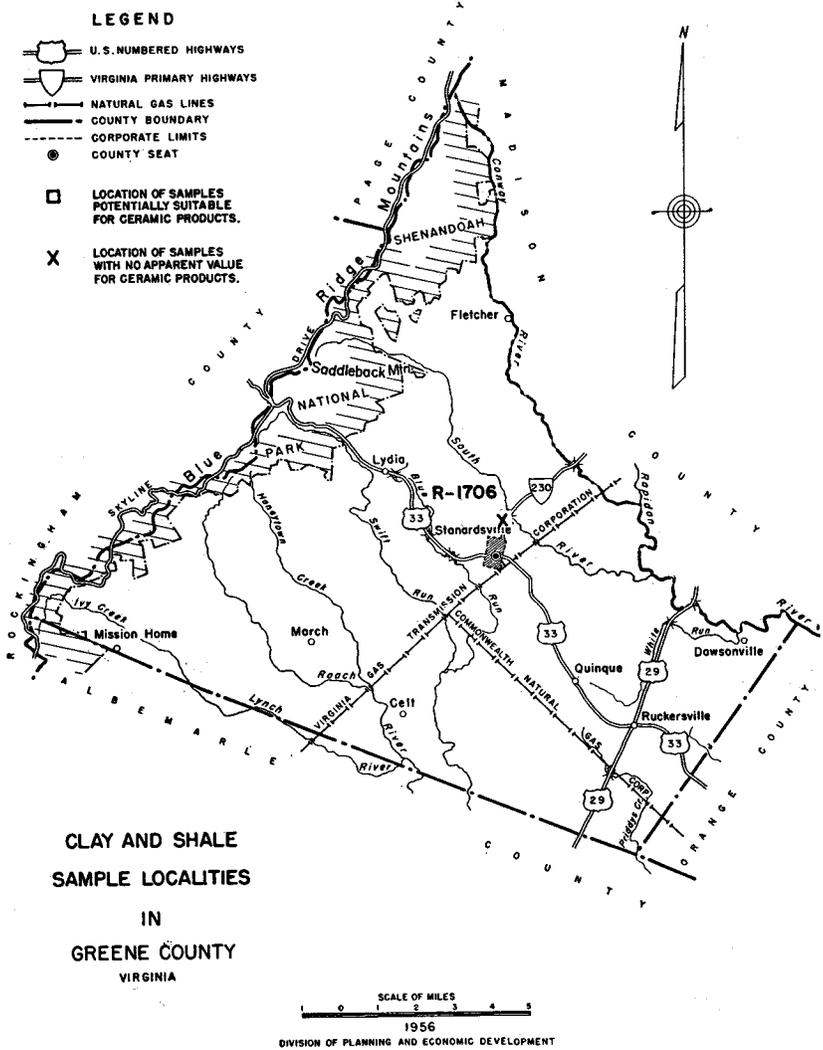
*Raw Properties:* Plastic, short working, requires 22 percent water for plasticity, no drying defects, 3.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	3.0	20.1	2.76
2000	Lt. red	Fairly hard	6.5	15.3	2.65
2100	Dull dk. red	Hard	8.0	10.2	2.60
2200	Dk. red brown	Very hard	10.0	6.5	2.45
2300	Dk. brown	.....	.....	6.0	2.16
2400	Very dk. brown	.....	Expanded	13.2	.....

*Bloating Test:* Slight expansion, not adequate for aggregate.

*Potential Use:* Common brick.



Location Map of Greene County

## GREENE COUNTY

One sample was collected in Greene County from clay of Recent age. Laboratory testing indicates the following potential use for the raw material sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-1706	Recent (?) clay	None

SAMPLE: R-1706

County: Greene

*Locality:* Outcrop on the northwest side of State Highway 230 approximately  $1\frac{1}{4}$  miles northeast of Stanardsville.

*Description:* An exposure of reddish-brown clay, 10 feet in height, was sampled for a distance of 160 feet along the roadcut. The clay weathers to form small angular fragments and contains angular grains of quartz. Some of the clay contains yellowish-brown mottled zones. The clay may have been derived from the weathering of a granite.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of clay from exposure 10 feet in height.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 5.05

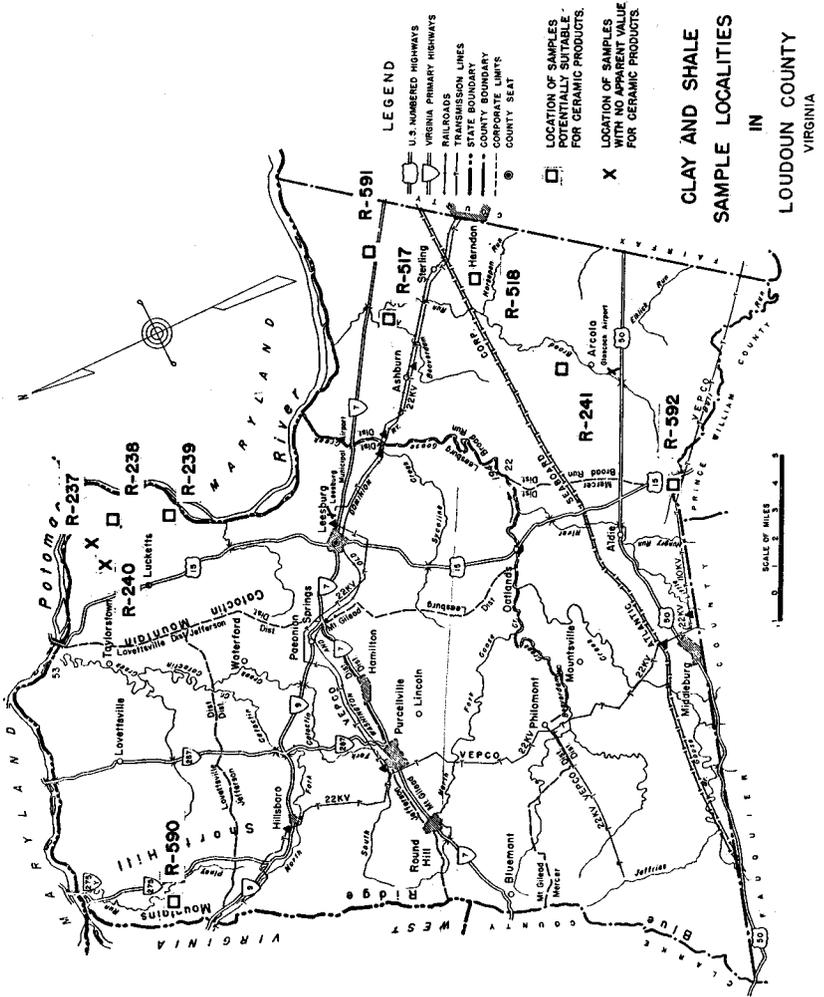
*Raw Properties:* Not too plastic, short and gritty working, requires 38 percent water for plasticity, no drying defects, 6.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Crumbly soft	10.0	31.0	2.89
2000	Dull dk. red	Crumbly soft	15.0	18.4	2.85
2100	Very dk. red	Crumbly soft	15.0	18.6	2.85
2200	Dk. red brown	Crumbly soft	15.0	17.3	2.85
2300	Black-brown	Crumbly soft	15.5	16.8	2.86
2400	Black-brown	Crumbly soft	17.5	13.7	2.81

*Bloating Test:* Negative

*Potential Use:* None



Location Map of Loudoun County

## LOUDOUN COUNTY

Samples were collected in Loudoun County from the Swift Run formation of early Paleozoic (?) age, and from shale, mudstone, and clay of Triassic age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-237	Triassic shale	None at present
R-238	Triassic shale	Brick
R-239	Triassic shale	Brick
R-240	Triassic shale	None at present
R-241	Triassic shale	Brick
R-517	Triassic shale and mudstone	Brick and sintered aggregate
R-518	Triassic shale and mudstone	Brick and sintered aggregate
R-590	Swift Run phyllite	Common brick
R-591	Triassic clay	Brick, tile, and low grade pottery
R-592	Triassic shale and mudstone	Brick and tile

SAMPLE: R-237

County: Loudoun

*Locality:* Outcrop along State Road 660 about one mile northeast of Lucketts.

*Description:* The outcrop consists of about six feet of dull red shale with an interbedded thin layer of micaceous, fine- to medium-grained sandstone. The rocks strike N. 10° W. and dip 25° SW., and are overlain by one foot of soil.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across six feet of shale.

*Type:* Shale

*Unfired strength:* Low

*Composition:* X-ray and petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	60-70	Kaolin	10-15
Sericite	15-20	Iron (oxides)	3-5
Feldspar	3-5		

*Raw Properties:* Not plastic, short and sandy working, requires 17 percent water for plasticity, no drying defects, 1.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red	Soft crumbly	1.5	25.8	2.67
2000	Dk. red brown	Soft crumbly	5.0	20.7	2.65
2100	Dk. Brown	Hard	6.0	13.3	2.69
2200	Dk. Brown	Hard	Expanded	....	....
2300	Dk. Brown	Very hard	Expanded	....	....

*Bloating Test:* Negative

*Potential Use:* None

*Extruded Bars (1/2'')*:

*Extrusion characteristics:* Poor, lamination and cracking

	<u>Unfired</u>	<u>Fired</u>
Transverse strength psi.:	250	1050

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

App. Sp. Gr.	2.74	% Shrinkage (length)	3.2
% Absorption	13.5		

SAMPLE: R-238

County: Loudoun

*Locality:* Outcrop along State Road 657 approximately two miles east of Lucketts.

*Description:* The outcrop consists of 30 feet of dull-red shale and a few interbedded thin layers of fine- to medium-grained, red and gray sandstone. The rocks strike N. 43° W. and dip 20° SW., and are overlain by one foot of soil.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 25 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 7.1

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	60 ±	Kaolin	20 ±
Sericite	20-25	Iron (oxides)	3-5
Feldspar	5 ±		

*Raw Properties:* Not plastic, short and gritty working, requires 18.0 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Soft crumbly	2.5	22.3	2.75
2000	Dk. brown	Soft crumbly	4.5	14.5	2.71
2100	Dk. brown	Hard	6.0	11.4	2.62
2200	Dk. brown	Steel hard	8.5	5.7	2.59
2300	Dk. brown	Steel hard	10.0	3.4	2.20

*Bloating Test:* Negative

*Potential Use:* Brick

*Extruded Bars (1/2'')*:

*Extrusion characteristics:* Poor

	<u>Unfired</u>	<u>Fired</u>
Transverse strength psi.:	76.0	420

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

App. Sp. Gr.	269	% Shrinkage (length)	4.5
% Absorption	8.5		

SAMPLE: R-239

County: Loudoun

*Locality:* Outcrop along State Road 656 approximately three miles southeast of Lucketts.

*Description:* The outcrop, which is exposed for a distance of 75 feet, consists of 10 feet of dull-red shale and a few interbedded layers of sandstone. The rocks strike N. 45° E. and dip to the northwest and are overlain by one foot of soil.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across eight feet of shale.

*Type:* Shale

*Unfired strength:* Below average

*pH:* 8.60

*Raw Properties:* Not plastic, short and sandy working, requires 20 percent water for plasticity, no drying defects, 5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Soft crumbly	4.0	25.9	2.77
2000	Red	Soft crumbly	4.0	21.6	2.62
2100	Dk. red brown	Hard	5.5	12.4	2.32
2200	Black brown	Steel hard	9.5	4.0	2.12

*Bloating Test:* Negative

*Potential Use:* Brick

SAMPLE: R-240

County: Loudoun

*Locality:* Outcrop on the north side of State Road 656 approximately two miles northeast of Lucketts.

*Description:* The outcrop consists of about 25 feet of dull-red shale with a few interbedded thin layers of fine- to medium-grained, gray sandstone.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 25 feet of shale.

*Type:* Shale

*Unfired strength:* Below average

*pH:* 9.0

*Raw Properties:* Not plastic, short and sandy working, requires 20 percent water for plasticity, no drying defects, 5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Soft crumbly	0.5	30.3	2.63
2000	Red	Soft crumbly	0.5	32.4	2.69
2100	Dk. red	Soft crumbly	0.5	28.1	2.65
2200	Dk. brown	Soft crumbly	5.0	16.4	2.65
2300	Black brown	Steel hard	10.0	3.9	2.35
2400	Black brown	.....	Expanded	.....	.....

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-241

County: Loudoun

*Locality:* Outcrop along State Road 659 about one mile north of Arcola.*Description:* The outcrop consists of about five feet of shale with interbedded thin layers of sandstone. The rocks strike N. 50° E. and dip 20° NW., and are overlain by about three feet of soil.*Formation or age:* Triassic*Sampled interval:* Composite sample across five feet of shale.*Type:* Shale*Unfired strength:* Low*pH:* 7.2*Raw Properties:* Not plastic, short and gritty working, requires 21.5 percent water for plasticity, no drying defects, 5 percent drying shrinkage.*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Soft crumbly	4.0	23.8	2.70
2000	Dk. red brown	Fairly hard	5.0	6.0	2.65
2100	Dk. brown	Very hard	10.0	2.2	2.60
2200	Dk. brown	Steel hard	Expanded	.....	2.28
2300	Dk. brown	Steel hard	Expanded	.....	.....

*Bloating Test:* Negative*Potential Use:* Brick*Extruded Bars (1/2'')*:*Extrusion characteristics:* Very poor

	<u>Unfired</u>	<u>Fired</u>
Transverse strength psi.:	35.0	450

Miniature brick (pressed at 5,000 psi., and fired to 1900°F. with one hour soak):

Approx. Sp. Gr.	2.65	% Shrinkage	2.8
% Absorption	10.0		

SAMPLE: R-517

County: Loudoun

*Locality:* Outcrop along State Road 607 approximately 2½ miles northwest of Nokes.

*Description:* The outcrop, which is exposed for a distance of 270 feet, consists of 25 feet of reddish-brown fissile shale and reddish-brown mudstone, both of which weather to form angular fragments. The rocks strike N. 20° E. and dip 25° NW. Similar shale crops out in a field to the east.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 25 feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Low

*pH:* 8.45

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50-60	Kaolin	5±
Albite	15-20	Montmorillonite	3±
Mica	5±	Iron (OH)x	3-5

*Raw Properties:* Not plastic, short and gritty working, requires 18 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. orange buff	Soft crumbly	4.5	16.6	2.62
2000	Dk. orange buff	Soft crumbly	4.5	16.5	2.65
2100	Red brown	Fairly hard	5.0	11.2	2.66
2200	Dk. brown	.....	Expanded	1.8	1.79

*Bloating Test:* Negative

*Potential Use:* Common brick 2150° F. and probably sintered aggregate.

SAMPLE: R-518

County: Loudoun

*Locality:* Outcrop at the junction of State Roads 606 and 775 about  $2\frac{1}{4}$  miles southwest of Sterling.

*Description:* The outcrop consists of three feet of weathered reddish-brown shale and mudstone, both of which weather to form angular fragments. The rocks strike N.15° E. and dip 20° NW., and are overlain by up to two feet of soil.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across three feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Low

*pH:* 6.9

*Raw Properties:* Not plastic, short and gritty working, requires 19 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	4.5	15.2	2.62
2000	Dk. buff	Soft crumbly	5.5	13.1	2.63
2100	Red brown	Very hard	9.0	5.9	2.57
2200	Brown	.....	Expanded	....	1.59

*Bloating Test:* Negative

*Potential Use:* Common brick and probably sintered aggregate.

SAMPLE: R-590

County: Loudoun

*Locality:* Outcrop on a private road located north of State Road 686 about 2½ miles northwest of Neersville.

*Description:* The outcrop, which is exposed for a distance of 150 feet, consists of medium-gray phyllite that contains blebs of white sericite. The phyllite is in the upper portion of the Swift Run formation and is reported to be 50 to 100 feet thick. The cleavage strikes northeast and dips 50° NW. The rocks have five feet of overburden.

*Formation or age:* Swift Run formation

*Sampled interval:* Composite sample of phyllite exposed for a distance of 150 feet.

*Type:* Phyllite

*Unfired strength:* Low

*pH:* 7.4

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	40 ±	Kaolin	5-8
Feldspar	5 ±	Montmorillonite-chlorite	3 ±
Sericite	40 ±	Iron (oxides)	1 ±

*Raw Properties:* Fair plasticity, smooth and slightly short working, requires 22.0 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. brown buff	Soft crumbly	6.0	8.9	2.61
2000	Dk. brown buff	Soft crumbly	7.0	8.3	2.62
2100	Dk. brown	Steel hard	9.5	1.0	2.61
2200	Near black	Steel hard	Expanded	0.9	1.82
2300	.....	(Melted)	.....	....	....

*Bloating Test:* Negative

*Potential Use:* Probably will make common brick.

SAMPLE: R-591

County: Loudoun

*Locality:* Outcrop on State Highway 7 about two miles northeast of Sterling.

*Description:* An exposure of reddish-brown, moderate-red and dark yellowish-orange clay, 12 feet in height, extends for a distance of 675 feet along the roadcut. This clay is derived from the weathering of Triassic shale and mudstone. Partially weathered shale is exposed at the southeastern and northwestern ends of the roadcut. The clay is overlain by approximately three feet of sand and gravel.

*Formation or age:* Triassic

*Sampled interval:* Sample of clay from exposure 12 feet in height.

*Type:* Clay

*Unfired strength:* Above average

*pH:* 5.2

*Raw Properties:* Plastic, smooth working, requires 31.0 percent water for plasticity, no drying defects, 6.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	8.5	13.3	2.52
2000	Orange buff	Soft crumbly	9.5	12.8	2.53
2100	Lt. red	Hard	10.0	8.7	2.46
2200	Red brown	Very hard	10.0	6.6	2.41
2300	Dk. brown	Steel hard	11.5	4.8	2.39
2400	Near black	Steel hard	12.5	2.5	2.38

*Bloating Test:* Negative

*Potential Use:* Brick, tile, and low grade pottery.

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

App. Sp. Gr.	2.68	% Shrinkage	2.3
% Absorption	9.6	Hardness	Very hard

SAMPLE: R-592

County: Loudoun

*Locality:* Outcrop on U. S. Highway 15 about  $2\frac{1}{4}$  miles south of the junction of U. S. Highways 15 and 50.

*Description:* The outcrop consists of about 15 feet of reddish-brown shale and mudstone, both of which weather to form angular fragments. The rocks strike N.10° E. and dip 40° to 45° NW.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 15 feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Average

*pH:* 5.7

*Raw Properties:* Fairly plastic, smooth working, requires 28.0 percent water for plasticity, no drying defects, 2.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	3.0	22.3	2.71
2000	Lt. red brown	Very hard	7.0	14.8	2.68
2100	Red brown	Steel hard	10.0	9.7	2.65
2200	Dk. brown	Steel hard	12.0	5.2	2.57
2300	Dk. brown	Steel hard	14.0	2.6	2.25
2400	Near black	Steel hard	Expanded	....	2.08

*Bloating Test:* Negative

*Potential Use:* Brick and tile (the working properties of this shale are good).



## MADISON COUNTY

Samples were collected in Madison County from clays of Recent age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-1707	Recent (?) clay	None
R-1708	Recent (?) clay	Might be suitable for brick or tile
R-1709	Recent (?) clay	None
R-1710	Recent (?) clay	None

SAMPLE: R-1707

County: Madison

*Locality:* Outcrop on the southeast side of State Road 620 approximately  $2\frac{1}{2}$  miles southwest of Madison Mills and  $1\frac{3}{8}$  miles southwest of the intersection of State Road 620 and State Highway 230.

*Description:* An exposure of dark reddish-brown alluvial clay, up to five feet in height, was sampled for a distance of 100 feet. Vertical auger holes drilled in the exposure encountered clay to a depth of three feet. The clay contains quartz and weathers to form angular fragments. Other nearby ridges and hills along the Rapidan River are capped by similar alluvial clays.

*Formation or age:* Recent (?)

*Sampled interval:* Sample from eight feet of clay.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 5.00

*Raw Properties:* Not too plastic, short and fairly smooth working, requires 34 percent water for plasticity, no drying defects, 6.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Crumbly soft	9.0	25.8	2.98
2000	Dk. red	Crumbly soft	14.0	16.3	2.97
2100	Dk. red	Crumbly soft	14.0	16.0	2.96
2200	Dk. red-brown	Crumbly hard	14.0	14.8	2.95
2300	Black-brown	Crumbly hard	15.0	13.4	2.94
2400	Black-brown	Fairly hard	15.5	10.8	2.88

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-1708

County: Madison

*Locality:* Outcrop is located one-quarter of a mile west of State Road 604 on the flood plain of the Robinson River and approximately three miles northeast of Madison.

*Description:* Auger holes were drilled in a 145 by 155 foot tract located approximately 40 feet northwest of a private road. Medium-gray and greenish-gray clays were encountered in auger holes drilled to a depth of five feet. In two auger holes the clay became progressively more sandy with depth. Some of the clay contains yellowish-brown and yellowish-green mottled zones. The clays contain subangular grains of quartz. An overburden of soil six inches in thickness is present.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of five feet of clay from auger hole.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 5.20

*Raw Properties:* Plastic, fairly long and gritty working, requires 24 percent water for plasticity, no drying defect, 8.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Crumbly soft	6.0	14.3	2.55
2000	Dull med. red	Fairly hard	10.0	8.8	2.44
2100	Red-brown	Very hard	10.0	6.3	2.41
2200	Red-gray	Steel hard	12.5	2.9	2.36
2300	Brownish-gray	.....	11.0	2.0	2.17
2400	.....	.....	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* Might be suitable for brick or tile.

SAMPLE: R-1709

County: Madison

*Locality:* Outcrop on the southwest side of State Road 613 approximately  $3\frac{1}{4}$  miles west of Wolfstown and  $1\frac{1}{4}$  miles west of the intersection of State Road 613 and State Highway 230.

*Description:* An exposure of moderate-brown colluvial clay, four feet in height, extends for a distance of 120 feet. The clay contains subangular grains of quartz. A few are intermixed with the clay.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of clay from exposure four feet in height.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 5.60

*Raw Properties:* Plastic, fairly long and gritty working, requires 29 percent water for plasticity, no drying defects, 7.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Lt. red-buff	Crumbly soft	6.0	20.3	2.66
2000	Dull med. red	Crumbly hard	9.5	14.4	2.62
2100	Dk. red	Hard	11.0	11.8	2.56
2200	Dk. red-brown	Hard	11.0	2.0	2.31
2300	Black-brown	Steel hard	14.5	2.6	2.39
2400	Black-brown	Steel hard	15.0	2.7	2.40

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-1710

County: Madison

*Locality:* Outcrop on the east side of State Road 621 approximately  $3\frac{3}{4}$  miles south of Wolfstown and half a mile northwest of the intersection of State Roads 621 and 633.

*Description:* An exposure of dark reddish-brown alluvial clay, up to five feet in height, was sampled for a distance of 255 feet. The clay weathers to form light brown angular fragments. Subangular grains of quartz occur in the clay. The exposure is covered by a thin cap of gravel and soil.

*Formation or age:* Recent (?)

*Sampled interval:* Sample from exposure up to five feet in height.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 5.15

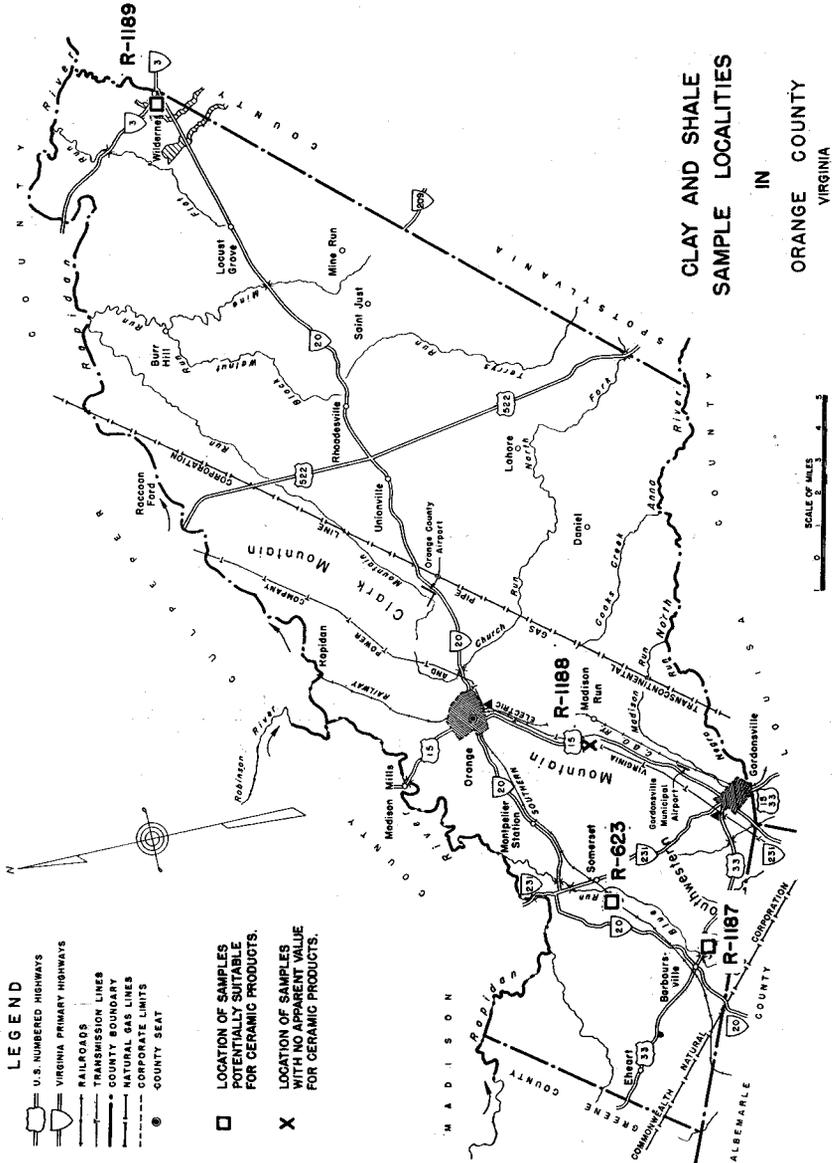
*Raw Properties:* Fairly plastic, short and gritty working, requires 42 percent water for plasticity, no drying defects, 6.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Lt. red	Crumbly soft	9.0	24.2	2.86
2000	Dull med. red	Crumbly hard	14.0	14.6	2.83
2100	Dk. red	Hard	14.0	9.9	2.81
2200	Dk. red-brown	Hard	14.5	12.5	2.79
2300	Black-brown	Very hard	15.0	10.8	2.77
2400	Black-brown	Very hard	15.0	8.6	2.72

*Bloating Test:* Negative

*Potential Use:* None



Location Map of Orange County

## ORANGE COUNTY

Samples were collected in Orange County from phyllite of Precambrian or early Paleozoic age, shale and mudstone of Triassic age, and clay of Recent (?) age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-623	Triassic shale and mudstone	Brick
R-1187	Triassic shale	Common brick
R-1188	Recent (?) clay	None at present
R-1189	Precambrian or early Paleozoic phyllite	Common brick

SAMPLE: R-623

County: Orange

*Locality:* Property of the Webster Brick Company located on the north-west side of State Road 655, just southwest of Somerset P. O. Triassic shale and mudstone are obtained from a pit located on the property.

*Formation or age:* Triassic

*Sampled interval:* Sample collected from stockpile.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.3

*Raw properties:* Fairly plastic, slightly short working, requires 19 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	20-30	Kaolin	30-40
Sericite	15-20	Iron (oxides)	5±
Feldspar	8-10		

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. orange buff	Soft crumbly	1.0	17.7	2.68
2000	Dk. red brown	Very hard	2.0	7.2	2.56
2100	Dk. brown	Steel hard	6.0	4.1	2.30
2200	Brown	Steel hard	Expanded	...	2.12
2300	Brown	Steel hard	Expanded	...	2.00
2400	.....	(Melted)	.....	...	....

*Bloating Test:* Negative

*Potential Use:* Brick

*Extruded Bars (1/2"):*

*Extrusion characteristics:* Good, no laminations

	Unfired	Fired
Transverse strength psi.:	81.0	1750

Miniature brick (pressed at 5,000 psi., and fired to 1900° F. with one hour soak):

App. Sp. Gr.	2.68	% Shrinkage	5.4
% Absorption	5.5		

SAMPLE: R-1187

County: Orange

*Locality:* Outcrop at the junction of U. S. Highway 33 and State Road 678 about three quarters of a mile southeast of Barbourville.

*Description:* The exposure, which is seven feet high, consists of weathered moderate reddish-brown mudstone and medium-grained, gray and dark reddish-brown sandstone. These rocks are exposed for a distance of 200 feet along U. S. Highway 33.

*Formation or age:* Triassic(?)

*Sampled interval:* Composite sample of mudstone from exposure seven feet in height.

*Type:* Mudstone

*Unfired strength:* Low

*pH:* 5.00

*Raw Properties:* Fairly plastic, short and gritty working, requires 29 percent water for plasticity, no drying defects, 4.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	4.5	25.2	2.77
2000	Lt. red	Soft crumbly	6.0	20.1	2.78
2100	Dull red	Fairly hard	9.0	16.6	2.76
2200	Red brown	Hard	9.0	14.4	2.75
2300	Dk. red brown	Hard	11.0	10.5	2.70
2400	Dk. brown	Very hard	14.0	6.8	2.65

*Bloating Test:* Negative

*Potential Use:* Could probably be used for common brick, if the material will vitrify with longer heat treatment.

SAMPLE: R-1188

County: Orange

*Locality:* Outcrop along State Road 639 approximately four miles southwest of Orange.

*Description:* An exposure of reddish-brown clay, seven feet in height, extends for a distance of 720 feet along the roadcut. Weathered moderate reddish-orange schist is exposed at the southeastern end of the roadcut.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of clay from exposure seven feet in height.

*Type:* Clay

*Unfired strength:* Average

*pH:* 5.42

*Raw Properties:* Plastic, slightly sticky and gritty working, requires 35 percent water for plasticity, no drying defects, 9.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red	Soft crumbly	10.5	23.4	2.96
2000	Dull red	Hard crumbly	14.5	15.1	2.95
2100	Dull red	Fairly hard	16.0	9.8	2.90
2200	Red brown	Hard	16.0	9.6	2.87
2300	Dk. red brown	Very hard	18.0	8.0	2.85
2400	.....	(Melted)	....	...	....

*Bloating Test:* Negative

*Potential Use:* None (unless mixed with another clay).

SAMPLE: R-1189

County: Orange

*Locality:* Outcrop along State Highway 20, just southwest of Wilderness the intersection of State Highways 3 and 20.

*Description:* The outcrop, which is exposed for a distance of 450 feet consists of about 25 feet of medium-gray and dark greenish-gray phyllite and a few interbedded layers of medium-grained, light-gray and yellowish-brown sandstone. The cleavage of the rocks strikes N. 10° E. and the dip is almost vertical. The rocks are overlain by up to five feet of clay.

*Formation or age:* Precambrian or early Paleozoic.

*Sampled interval:* Composite sample across 20 feet of phyllite.

*Type:* Phyllite

*Unfired strength:* Low

*pH:* 5.70

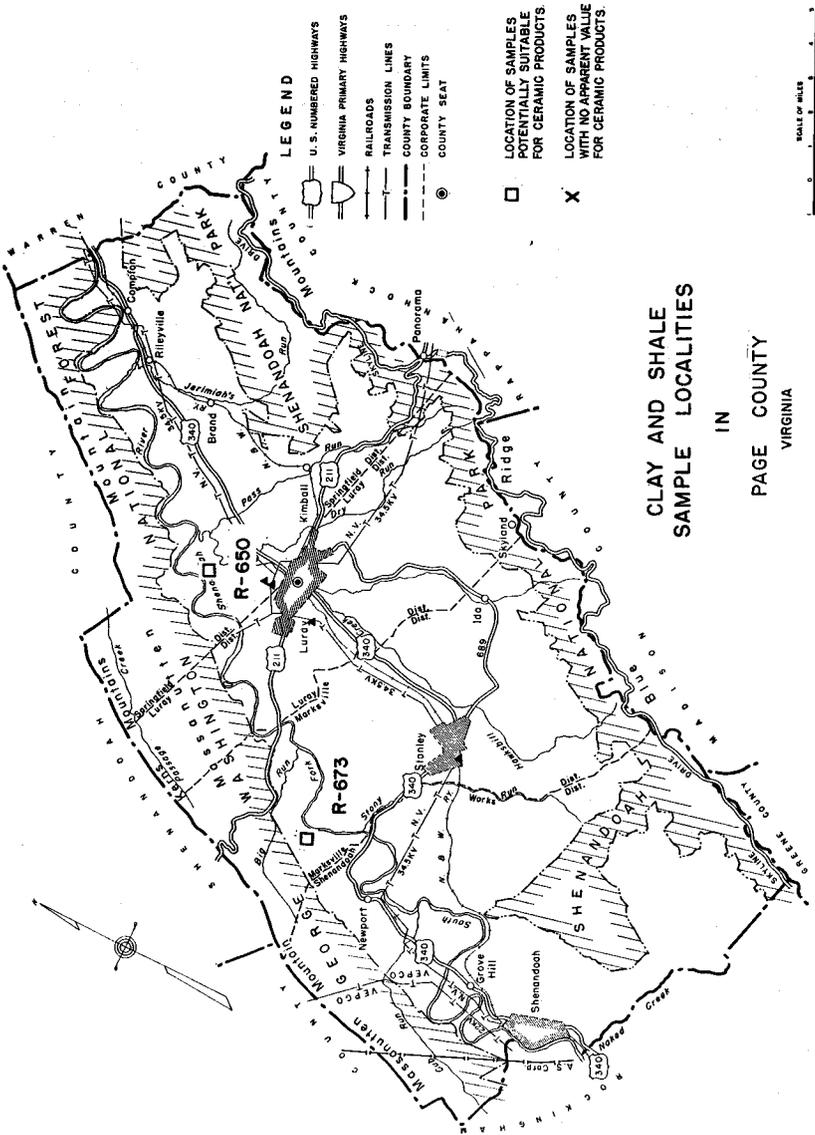
*Raw Properties:* Not too plastic, short and slightly gritty working, requires 29 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Reddish buff	Soft crumbly	4.5	24.5	2.65
2000	Reddish buff	Soft crumbly	5.0	19.1	2.63
2100	Dull red	Fairly hard	8.0	12.4	2.60
2200	Dk. red brown	Very hard	8.0	8.1	2.54
2300	Dk. brown	Steel hard	11.0	2.8	2.34
2400	Dk. brown	Steel hard	11.0	2.5	2.14

*Bloating Test:* Slight expansion (not adequate for aggregate).

*Potential Use:* Could probably be used for common red brick.



CLAY AND SHALE  
SAMPLE LOCALITIES  
IN  
PAGE COUNTY  
VIRGINIA

Location Map of Page County

## PAGE COUNTY

Samples were collected in Page County from the Martinsburg shale of Ordovician age and from clay of Recent (?) age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential Use</u>
R-650	Recent (?) clay	Common brick
R-673	Martinsburg shale	Common brick, tile, and light-weight aggregate

SAMPLE: R-650

County: Page

*Locality:* Outcrop on the northwest side of State Road 654 approximately  $2 \frac{3}{4}$  miles northwest of Luray.

*Description:* An exposure of pale yellowish-orange and pale red saprolitic Clay, seven feet in height, extends for a distance of 520 feet along the roadcut. An auger hole showed that the clay extends to a depth of at least four feet. Blue shale is exposed at the southwestern end of the exposure.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of clay from an exposure 11 feet in height.

*Type:* Clay

*Unfired strength:* Low

*pH:* 6.30

*Raw Properties:* Fair plasticity, slightly short working, requires 32 percent water for plasticity, no drying defects, 6.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	8.0	18.8	2.62
2000	Buff red	Fairly hard	10.5	14.9	1.59
2100	Dk. red	Hard	11.5	11.1	2.53
2200	Dk. red brown	Very hard	13.5	5.0	2.39
2300	Dk. brown	Steel hard	13.5	1.4	2.13
2400	Grayish brown	.....	Expanded	11.5	2.03

*Bloating Test:* Negative

*Potential Use:* Common red brick

SAMPLE: R-673

County: Page

*Locality:* Outcrop on the west side of State Road 615 about half a mile north of Battle Creek.

*Description:* The outcrop consists of about 135 feet of olive-gray shale with interbedded layers of thin-to medium-bedded, fine-grained, brown sandstone. The shale weathers to form grayish-orange angular fragments. The rocks strike N. 25°E. and dip 55°SE., and are overlain by two feet of soil.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 135 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 4.80

*Raw Properties:* Fairly plastic, smooth working, requires 28 percent water for plasticity, no drying defects, 3.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	4.5	22.8	2.79
2000	Dk. buff	Fairly hard	10.0	14.2	2.74
2100	Red	Hard	10.0	9.2	2.67
2200	Dk. red brown	Very hard	12.5	8.8	2.59
2300	Dk. brown	Steel hard	12.5	3.4	2.54
2400	Dk. brown	Steel hard	12.5	2.0	2.46

*Bloating Test:* Unweathered material shows good bloating.

*Potential Use:* Common brick, tile, and lightweight aggregate.



## PRINCE WILLIAM COUNTY

Samples were collected in Prince William County from the Quantico slate of Ordovician age, shale and mudstone of Triassic age, clay of Cretaceous age, and clay of Recent (?) age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-230	Cretaceous clay	None at present
R-232	Cretaceous clay	None at present
R-233	Cretaceous clay	None at present
R-234	Cretaceous clay	Common brick and tile
R-420	Triassic shale	None at present
R-421	Quantico slate	None at present
R-422	Triassic shale and mudstone	Sintered aggregate
R-423	Triassic shale and mudstone	Brick and tile
R-531	Quantico slate	None at present
R-599	Triassic shale and clay	None at present
R-600	Triassic shale and mudstone	Common brick
R-622	Triassic shale and mudstone	Brick
R-745	Quantico slate	Brick
R-1543	Recent (?) clay	Brick and tile

SAMPLE: R-230

County: Prince William

*Locality:* Outcrop along the Richmond, Fredericksburg and Potomac Railroad about one mile south of Neabsco.

*Description:* An exposure of dark yellowish-orange clay, 20 feet in height, extends for a distance of 245 feet along the railroad cut. This clay contains some carbonaceous material and weathers to form small rectangular fragments. The clay is overlain by four to twelve feet of sand and is underlain by sand.

*Formation or age:* Cretaceous (?)

*Sampled interval:* Sample of clay from exposure 20 feet in height.

*Type:* Clay

*Unfired strength:* Above average

*pH:* 5.50

*Raw Properties:* Very plastic, smooth and sticky working, requires 36 percent water for plasticity, 5.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Red buff	Soft crumbly	11.0	16.9	2.66
2000	Red	Fairly hard	15.0	10.6	2.63
2100	Dk. red	Hard	15.5	7.3	2.64
2200	Dk. red brown	Very hard	19.0	6.0	2.65
2300	Black brown	Steel hard	19.0	9.4	2.35
2400	Black brown	.....	15.0	13.6	2.28

*Bloating Test:* Negative

*Potential Use:* None (fired specimen showed scumming).

SAMPLE: R-232

County: Prince William

*Locality:* Outcrop along the Richmond, Fredericksburg and Potomac Railroad about one mile south of Cherry Hill.

*Description:* An exposure of olive-brown clay, 3 to 10 feet in height, extends for a distance of 765 feet along the railroad cut. This clay weathers to form small rectangular fragments and has up to 10 feet of overburden.

*Formation or age:* Cretaceous (?)

*Sampled interval:* Sample of clay from exposure 10 feet in height.

*Type:* Clay

*Unfired strength:* Average

*pH:* 5.05

*Raw Properties:* Not too plastic, gritty and short working, requires 32 percent water for plasticity, no drying defects, 6 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red buff	Soft crumbly	10.0	16.2	2.66
2000	Red	Soft crumbly	11.0	13.2	2.68
2100	Dk. red	Soft crumbly	14.5	11.7	2.67
2200	Dk. red brown	Fairly hard	15.5	9.7	2.65
2300	Black brown	Very hard	17.5	5.6	2.43
2400	Black brown	.....	15.0	7.7	2.20

*Bloating Test:* Negative

*Potential Use:* None (fired specimen showed scumming).

SAMPLE: R-233

County: Prince William

*Locality:* Outcrop along State Road 635 about 1½ miles west of Cherry Hill.

*Description:* An exposure of olive-brown and rusty-brown clay, 16 feet in height, extends for a distance of 270 feet along the roadcut. This clay contains minor amounts of quartz and weathers to form small rectangular fragments. The clay has about two feet of sandy overburden.

*Formation or age:* Cretaceous (?)

*Sampled interval:* Sample of clay from exposure 16 feet in height.

*Type:* Clay

*Unfired strength:* Average

*pH:* 4.40

*Raw Properties:* Not too plastic, gritty and short working, requires 32 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Med. red	Soft crumbly	10.0	19.1	2.77
2000	Med. red	Soft crumbly	14.0	15.4	2.70
2100	Dk. red	Fairly hard	16.0	12.3	2.72
2200	Red brown	Fairly hard	16.0	11.3	2.75
2300	Dk. red brown	Hard	19.5	5.5	2.60
2400	Dk. red brown	Very hard	19.5	4.6	2.54

*Bloating Test:* Negative

*Potential Use:* None (fired specimen showed scumming).

SAMPLE: R-234

County: Prince William

*Locality:* Outcrop along the Richmond, Fredericksburg and Potomac Railroad about three miles southeast of Dumfries.

*Description:* The outcrop, which is exposed for a distance of 480 feet, consists of lenticular body of light-brown and pale-olive clay that has a maximum thickness of about 10 feet. This clay contains some quartz and weathers to form angular fragments. The lower portion of the deposit is composed of pale-olive clay and the upper portion consists of light-brown clay. The clay is overlain by about one foot of sandy overburden and is underlain by gravel at the northern and southern end of the exposure.

*Formation or age:* Cretaceous (?)

*Sampled interval:* Sample of clay from exposure 10 feet in height.

*Type:* Clay

*Unfired strength:* Average

*pH:* 4.70

*Raw Properties:* Fair plasticity, smooth and slightly gritty working, requires 31 percent water for plasticity, no drying defects, 5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Lt. orange buff	Soft crumbly	8.5	18.0	2.66
2000	Red	Fairly hard	14.0	9.8	2.59
2100	Dk. red	Very hard	14.0	6.2	2.52
2200	Dk. red brown	Steel hard	15.0	3.4	2.48
2300	Black brown	Steel hard	15.0	4.1	2.23
2400	Black brown		10.0	11.9	1.98

*Bloating Test:* Negative

*Potential Use:* Common brick and tile.

SAMPLE: R-420

County: Prince William

*Locality:* Outcrop on the north side of State Road 646 approximately three miles west of Independent Hill.

*Description:* Interbedded reddish-brown weathered shale and fine- to medium-grained micaceous sandstone are exposed in an outcrop eight feet high for a distance of 735 feet along the roadcut.

*Formation or age:* Triassic

*Sampled interval:* Composite sample of shale from outcrop eight feet in height.

*Type:* Shale

*Unfired strength:* Low

*pH:* 4.75

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	60 ±	Kaolin	2-3
Feldspar	10 ±	Iron (oxides)	5-8
Sericite	10 ±	Montmorillonite-chlorite	5-8

*Raw Properties:* Fairly plastic, slightly gritty and short working, requires 30 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Very Lt. red	Soft crumbly	4.0	25.4	2.71
2000	Lt. red	Soft crumbly	6.0	19.7	2.69
2100	Red	Fairly hard	9.0	14.2	2.66
2200	Dk. red brown	Hard	11.0	9.8	2.60
2300	Black brown	.....	13.5	4.0	2.33
2400	Black brown	.....	Expanded	17.1	2.15

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-421

County: Prince William

*Locality:* Outcrop along State Road 638 about 1¾ miles south of Agnewville.

*Description:* The outcrop, which extends for a distance of 170 feet, consists of about 125 feet of light and dark-gray slate with an interbedded thin layer of light-brown, micaceous sandstone. The cleavage strikes N. 35°E. and the dip varies from 70° SE., to vertical. The slate has seven feet of sandy overburden.

*Formation or age:* Quantico slate

*Sampled interval:* Composite sample across 125 feet of slate.

*Type:* Slate

*Unfired strength:* Low

*pH:* 5.8

*Raw Properties:* Not too plastic, fairly smooth working, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. ivory	Soft crumbly	4.0	25.0	2.57
2000	Lt. gray ivory	Soft crumbly	4.0	23.1	2.59
2100	Lt. gray	Soft crumbly	4.5	17.0	2.57
2200	Gray	Fairly hard	5.5	13.4	2.54
2300	Gray	Fairly hard	9.0	13.6	2.55
2400	Dk. gray	Very hard	10.0	8.4	2.48

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-422

County: Prince William

*Locality:* Outcrop in a quarry on the northwest side of State Road 607 at the Prince William-Fauquier County Line.

*Description:* The outcrop consists of 10 feet of medium-bedded, dull-red mudstone and dull-red shale, both of which weather to form angular fragments. The rocks in the quarry are nearly horizontal.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 10 feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Low

*pH:* 8.7

*Raw Properties:* Not plastic, short and gritty working, requires 14 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	0.5	18.0	2.57
2000	Dk. buff	Soft crumbly	0.5	15.4	2.38
2100	Brown	Soft crumbly	0.5	5.4	1.94
2200	.....	(Melted)	...	...	....

*Bloating Test:* Negative

*Potential Use:* This shale could probably be used for sintered lightweight aggregate.

SAMPLE: R-423

County: Prince William

*Locality:* Outcrop along State Road 646 about 2½ miles northwest of Aden.

*Description:* The outcrop, which is exposed for a distance of 820 feet, consists of about 130 feet of dull-red shale, mudstone, and interbedded thin layers of medium-grained, dull-red sandstone. The rocks strike N. 15° E. and dip 10° to 20° NW., and have two feet of overburden. At the northwestern end of the cut the beds are gently folded.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 125 feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Low

*pH:* 5.3

*Raw Properties:* Fairly plastic, short working, requires 25 percent water for plasticity, no drying defects, 2.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Reddish buff	Soft crumbly	5.5	21.3	2.68
2000	Dull med. red	Hard crumbly	6.0	14.4	2.63
2100	Reddish brown	.....	13.5	3.8	2.47
2200	Dk. red brown	.....	Expanded	8.3	1.91
2300	Dk. brown	.....	Expanded	16.2	2.14

*Bloating Test:* Negative

*Potential Use:* Brick and tile

SAMPLE: R-531

County: Prince William

*Locality:* Outcrop along State Road 629 about half a mile southwest of Dumfries.

*Description:* The outcrop, which is exposed for a distance of 168 feet, consists of 130 feet of medium-gray slate and interbedded thin layers of fine to-medium-grained, brownish sandstone. The slate weathers to form small rectangular blocks. The rocks strike N. 30° E. and dip 78° NW., and are overlain by two feet of sand and gravel. A small fault, which dips to the southeast, occurs near the southeastern end of the roadcut.

*Formation or age:* Quantico slate

*Sampled interval:* Composite sample across 125 feet of slate.

*Type:* Slate

*Unfired strength:* Very low

*pH:* 5.70

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	60±	Kaolin	5-8
Feldspar	5±	Iron (oxides)	1-2
Sericite	25±	Montmorillonite-chlorite	1-2

*Raw Properties:* Not plastic, very short working, no drying defects, 1.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Soft crumbly	2.0	28.2	2.73
2000	Tan	Soft crumbly	3.0	23.6	2.71
2100	Tannish brown	Fairly hard	4.0	18.2	2.69
2200	Gray brown	Hard	8.5	9.4	2.53
2300	Dk. brown	.....	Expanded	30.7	1.93
2400	.....	(Melted)	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-599

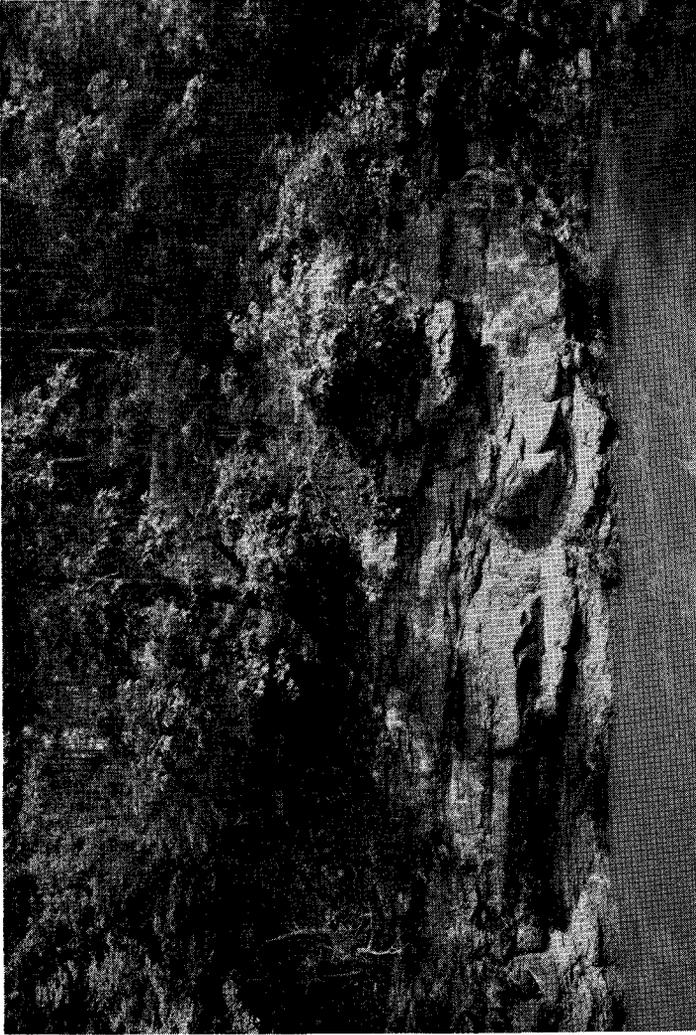
County: Prince William

*Locality:* Outcrop along State Highway 234, just east of Catharpin.*Description:* An exposure of weathered reddish-brown shale and clay, eight feet in height, extends for a distance of 765 feet along the roadcut. A few thin layers of fine-grained sandstone are interbedded with the shale.*Formation or age:* Triassic*Sampled interval:* Composite sample of shale and clay from exposure eight feet in height.*Type:* Shale and clay*Unfired strength:* Low*pH:* 5.60*Raw Properties:* Fairly plastic, smooth working, requires 27.0 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.*Fired Properties:*

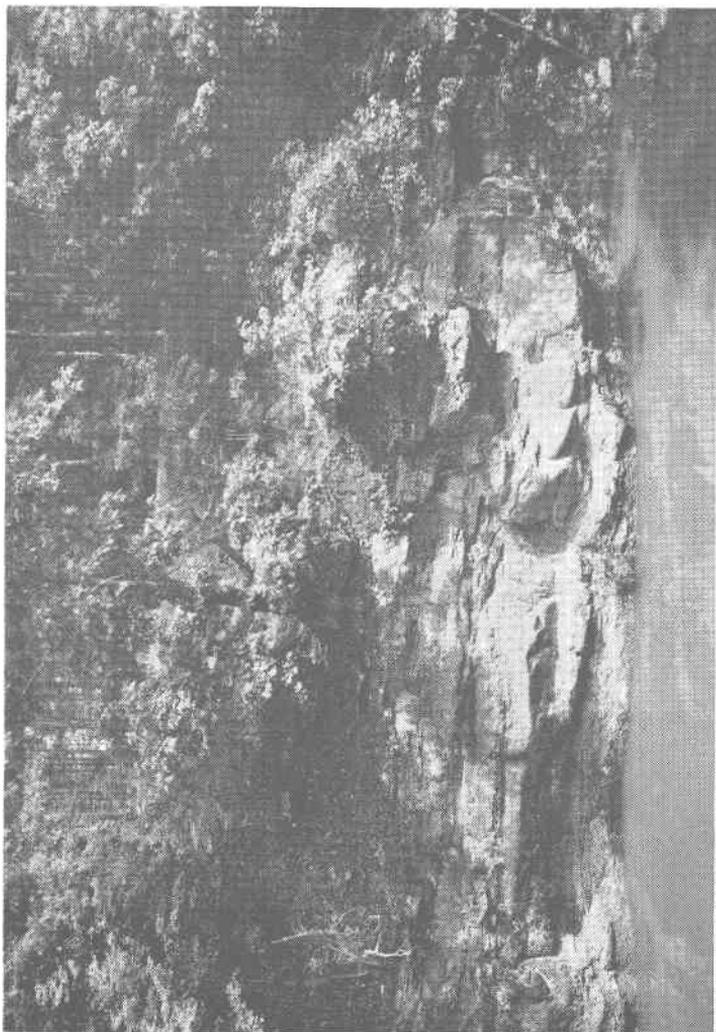
<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	5.0	20.0	2.63
2000	Buff	Fairly hard	6.0	16.0	2.59
2100	Red brown	Hard	6.5	11.0	2.55
2200	Dk. red brown	Very hard	9.5	9.9	2.55
2300	Brown black	Steel hard	10.5	3.5	2.47
2400	Brown black	Steel hard	11.0	3.6	2.46

*Bloating Test:* Negative*Potential Use:* None

## Plate 3



Outcrop of Triassic shale and mudstone (Sample R-600) along U. S. Highway 29 about 5½ miles northeast of Gainesville, Prince William County.



Outcrop of Triassic shale and mudstone (Sample R-600) along U. S. Highway 29 about 5½ miles northeast of Gainesville, Prince William County.

SAMPLE: R-600

County: Prince William

*Locality:* Outcrop along U. S. Highway 29 about 5½ miles northeast of Gainesville. (Plate 3).

*Description:* The outcrop consists of about 50 feet of reddish-brown shale and siltstone and interbedded layers of medium-grained, reddish-brown sandstone. The rocks strike N. 50° E. and dip about 20° NW., and are overlain by three feet of soil.

*Formation or age:* Triassic

*Sampled interval:* Composite sample across 45 feet of shale and siltstone.

*Type:* Shale

*Unfired strength:* Low

*pH:* 9.00

*Raw Properties:* Not plastic, short and gritty working, no drying defects, 2.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	4.0	17.5	2.42
2000	Red brown	Fairly hard	4.0	12.2	2.37
2100	Brown	Steel hard	8.0	0.5	2.12
2200	Brown	Steel hard	Expanded	0.6	1.72

*Bloating Test:* Negative

*Potential Use:* Probably will make common brick at 2050° F.

SAMPLE: R-622

County: Prince William

*Locality:* Property of the Woodbridge Clay Products Company located on the north side of State Road 661 about 1¾ miles south of Manassas. Triassic shale and mudstone are obtained from a pit located on the property.

*Formation or age:* Triassic

*Sampled interval:* Sample collected from the stockpile.

*Type:* Shale

*Unfired strength:* Low

*pH:* 7.9

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50-60	Kaolin	10 ±
Sericite	20-25	Iron (oxides)	5 ±
Feldspar	10 ±		

*Raw Properties:* Not plastic, very short working, requires 19 percent water for plasticity, no drying defects, 1 percent drying shrinkage.

*Fired Properties:*

<u>Temp. °F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx. Sp. Gr.</u>
1800	Dk. orange buff	Soft crumbly	2.5	14.4	2.71
2000	Dk. red brown	Steel hard	10.0	4.2	2.49
2100	.....	(Melted)	.....	.....	.....
2200	.....	(Melted)	Expanded	.....	.....

*Bloating Test:* Negative

*Potential Use:* Brick

*Extruded ½" Rods*

*Extrusion characteristics:* Good, smooth bars, no lamination.

	<u>Unfired</u>	<u>Fired 1900°F</u>
Transverse strength psi.:	83.0	850

Miniature brick (pressed at 5000 psi., and fired to 1900° F. with one hour soak):

App. Sp. Gr.	2.47	% Shrinkage	5.2
% Absorption	6.2		

SAMPLE: R-745

County: Prince William

*Locality:* Property of the Woodbridge Clay Products Company located at Woodbridge. Quantico slate and clay are obtained from a pit located on the property.

*Formation or age:* Quantico slate

*Sampled interval:* Sample collected from stockpile.

*Type:* Mixture of 80 percent slate + 20 percent clay

*pH:* 5.60

*Unfired strength:* Very low

*Raw Properties:* Short working, requires 25 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. buff	Soft crumbly	0.5	26.6	2.64
2000	Lt. buff	Soft crumbly	1.5	24.5	2.66
2100	Med. red	Soft crumbly	3.0	21.6	2.68
2200	Dk. red	Very hard	4.5	17.2	2.68
2300	Dk. brown	Steel hard	5.0	14.6	2.62
2400	Dk. brown	Steel hard	6.0	11.0	2.56

*Bloating Test:* Negative

*Potential Use:* Brick

SAMPLE: R-1543

County: Prince William

*Locality:* Outcrop in a field southwest of Linton Hall Military School approximately  $1\frac{3}{4}$  miles northwest of the junction of State Highway 28 and State Road 619.

*Description:* Light-gray and yellowish-brown alluvial clay was obtained from auger holes drilled to a depth of three feet.

*Formation or age:* Recent (?)

*Sampled interval:* Three feet of clay

*Type:* Clay

*Unfired strength:* Average

*pH:* 5.00

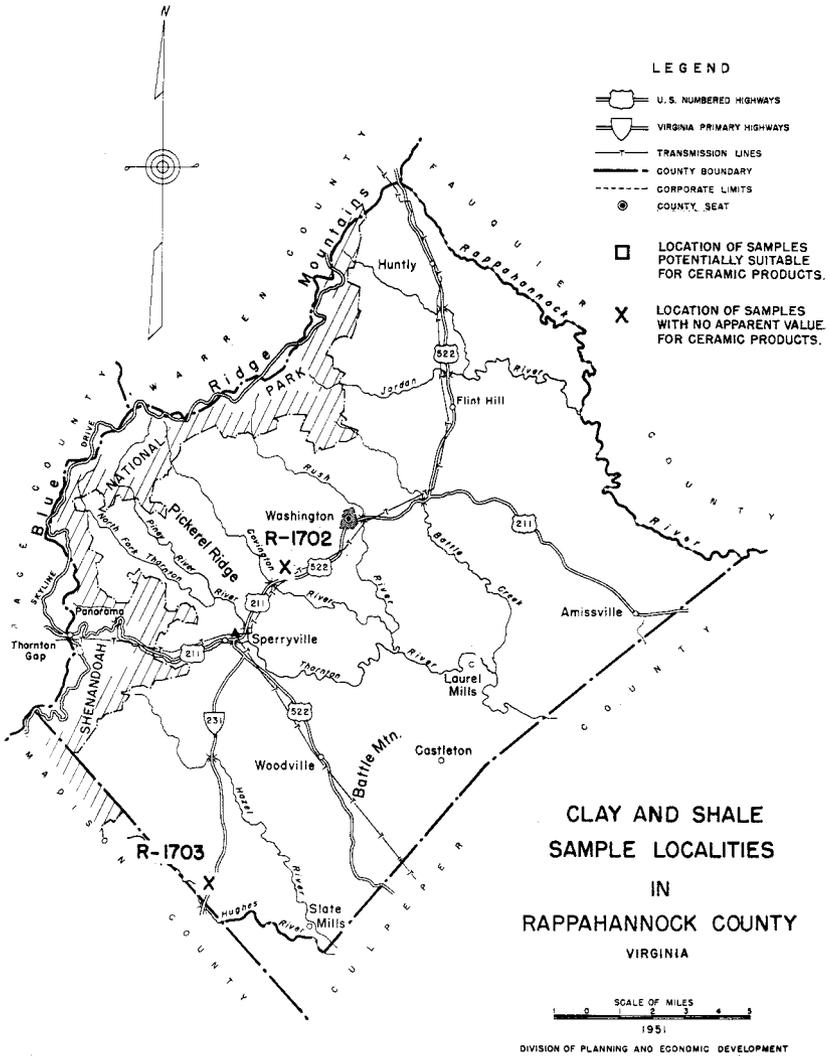
*Raw Properties:* Plastic, smooth working, requires 26 percent water for plasticity, no drying defects, 8.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red	Fairly hard	10.0	15.4	2.71
2000	Med. red	Hard	10.0	11.9	2.69
2100	Dk. red	Very hard	11.0	10.3	2.64
2200	Dk. red brown	.....	12.5	7.2	2.53
2300	Dk. brown	.....	13.5	3.9	2.32
2400	Dk. brown	.....	Expanded	15.4	2.12

*Bloating Test:* Negative

*Potential Use:* Brick and tile



Location Map of Rappahannock County

## RAPPAHANNOCK COUNTY

Samples were collected in Rappahannock County from clays of Recent age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-1702	Recent (?) clay	None
R-1703	Recent (?) clay	None

SAMPLE: R-1702

County: Rappahannock

*Locality:* Outcrop on the north side of U. S. Highway 211 approximately  $2\frac{3}{4}$  miles southwest of Washington.

*Description:* An exposure of dark reddish-brown and moderate reddish-brown clay, up to 12 feet in height, was sampled for a distance of 115 feet along the roadcut. The clay contains angular grains of quartz and it weathers to form angular fragments. Some of the clay contains light-gray mottled zones. The clay may be derived from the weathering of schist that contains interbedded quartzites.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of clay from exposure up to 12 feet in height.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 5.55

*Raw Properties:* Not too plastic, short and fatty working, requires 47 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Crumbly soft	6.5	34.6	2.69
2000	Dull red	Crumbly soft	10.0	26.6	2.65
2100	Dull dk. red	Crumbly soft	11.5	24.3	2.65
2200	Dk. red-brown	Crumbly soft	13.5	22.9	2.64
2300	Black-brown	Crumbly soft	13.5	20.5	2.66
2400	Black-brown	Crumbly soft	13.5	20.4	2.65

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-1703

County: Rappahannock

*Locality:* Outcrop on the northwest side of State Highway 231 approximately three quarters of a mile northeast of the Madison-Rappahannock County line.

*Description:* An exposure of moderate reddish-brown clay, up to 12 feet in height is exposed for a distance of 108 feet along the roadcut. The clay weathers to form small angular fragments and contains angular grains of quartz. Some of the clay contains light-gray mottled zones. The clay may be derived from the weathering of hypersthene granodiorite.

*Formation or age:* Recent (?)

*Sampled interval:* Sample of clay from exposure 12 feet in height.

*Type:* Clay

*Unfired strength:* Very low

*pH:* 5.05

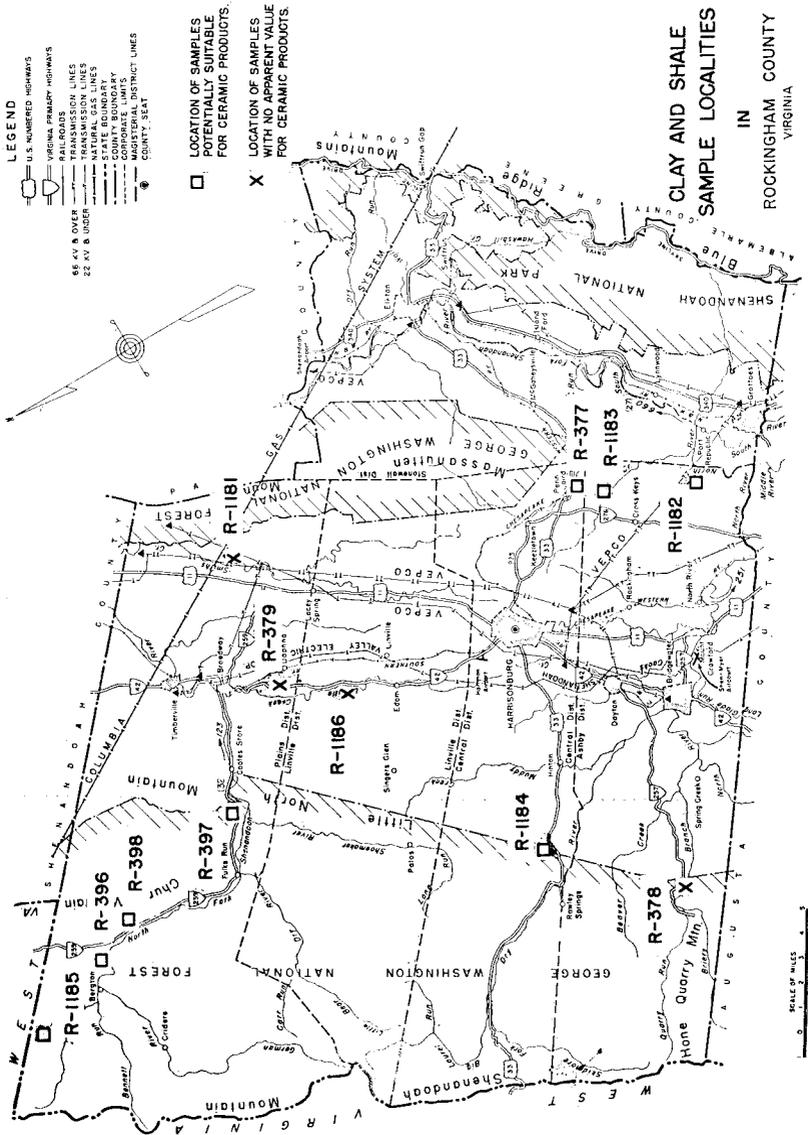
*Raw Properties:* Not too plastic, short and gritty working, requires 36 percent water for plasticity, no drying defects, 6.0 percent shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Red	Crumbly soft	8.5	31.2	2.87
2000	Very dk. red	Crumbly soft	11.5	21.7	2.78
2100	Dull red	Crumbly soft	11.5	20.6	2.73
2200	Dk. red brown	Crumbly soft	12.5	21.7	2.80
2300	Black-brown	Crumbly soft	12.5	17.3	2.76
2400	.....	.....	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* None



Location Map of Rockingham County

## ROCKINGHAM COUNTY

Samples were collected in Rockingham County from the Millboro shale, Brallier shale, and Chemung formation of Devonian age, and from the Martinsburg shale of Ordovician age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential Use</u>
R-377	Martinsburg shale	Brick and tile
R-378	Chemung shale	None at present
R-379	Martinsburg shale	None at present
R-396	Chemung shale	Common brick
R-397A	Weathered Brallier shale	Common brick
R-397B	Unweathered Brallier shale	Common brick and lightweight aggregate
R-398	Millboro shale and siltstone	Decorative brick
R-1181	Martinsburg shale	None at present
R-1182	Martinsburg shale	Common brick and tile
R-1183A	Unweathered Martinsburg shale	Common brick and possibly lightweight aggregate
R-1183B	Weathered Martinsburg shale	Common brick
R-1184	Brallier shale	Brick, tile, and lightweight aggregate
R-1185	Brallier shale	Brick and tile
R-1186A	Unweathered Martinsburg shale	None at present
R-1186B	Weathered Martinsburg shale	None at present

SAMPLE: R-377

County: Rockingham

*Locality:* Outcrop on the west side of State Road 655 approximately half a mile south of Penn Laird.

*Description:* The portion of the outcrop sampled consists of about 53 feet of dark-blue shale and interbedded thin layers of laminated brownish sandstone. The shale weathers to form tan and yellowish-orange angular fragments.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 50 feet of shale

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.9

*Raw Properties:* Fair plasticity, slightly gritty and smooth working, requires 17.0 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. brown	Soft crumbly	2.5	11.0	2.55
2000	Med. brown	Hard	3.5	6.8	2.49
2100	Med. brown	Very hard	3.5	5.9	2.50
2200	Dk. brown	Steel hard	7.5	1.7	2.45
2300	Dk. brown	Steel hard	7.5	1.7	2.46
2400	Near black	Steel hard	Expanded	0.8	2.00

*Bloating Test:* Negative

*Potential Use:* Brick and tile (Plate 7)

Miniature brick (pressed at 5000 psi., and fired to 1900° F. with one hour soak):

App. Sp. Gr.	2.70	% Shrinkage	2.3
% Absorption	5.6	Hardness	Steel hard

SAMPLE: R-378

County: Rockingham

*Locality:* Outcrop on the east side of State Highway 257 approximately one mile west of Briery Branch.

*Description:* The outcrop, which is exposed for a distance of about 100 feet, consists of 11 feet of shale with interbedded massive layers of gray to green sandstone. The shale weathers to form yellow, brown, and dark-gray fragments.

*Formation or age:* Chumung formation

*Sampled interval:* Composite sample across 11 feet of shale

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.9

*Raw Properties:* Not plastic, short and gritty working, requires 19.0 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Orange buff	Soft crumbly	2.0	14.8	2.35
2000	Red buff	Soft crumbly	2.5	11.9	2.34
2100	Red buff	Soft crumbly	2.5	10.2	2.34
2200	Med. brown	Fairly hard	4.0	7.2	2.34
2300	Med. brown	Fairly hard	4.0	7.1	2.36
2400	Near black	Steel hard	5.0	5.4	2.35

*Bloating Test:* Negative

*Potential Use:* None (fired specimen remained soft through 2200° F.)

SAMPLE: R-379

County: Rockingham

*Locality:* Outcrop on the west side of State Highway 42 approximately two miles southwest of Broadway.

*Description:* The outcrop, which is exposed for a distance of 200 feet, consists of 20 feet of dark-gray shale which weathers to form brownish-yellow angular fragments. Some of the shale is cut by small veins of calcite. The rocks strike N. 20° E. and dip 65° SE.

*Formation or age:* Martinsburg shale

*Sampled interval:* Sample across 20 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 8.8

*Raw Properties:* Slightly plastic, short working, requires 21.0 percent water for plasticity. No drying defects, 4.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Gray pink	Soft crumbly	Expanded	40.6	2.85
2000	Gray pink	Soft crumbly	Expanded	42.7	2.84
2100	Lt. buff	Soft crumbly	Expanded	40.4	2.78
2200	Orange buff	Soft crumbly	10.5	19.2	2.72
2300	Dk. buff	Fairly hard	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* None (very high in calcium, 2300° F. specimen disintegrated in water.)

SAMPLE: R-396

County: Rockingham

*Locality:* Outcrop on the northeast side of State Road 820 approximately 1.7 miles southeast of Bergton P. O.

*Description:* The outcrop consists of about 30 feet of brown and gray shale and interbedded layers of medium-to thick-bedded, greenish-gray sandstone.

*Formation of age:* Chemung formation.

*Sampled interval:* Composite sample across 25 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 7.70

*Raw Properties:* Not plastic, short and sandy working, requires 19.0 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	2.5	12.1	2.88
2000	Orange buff	Soft crumbly	3.5	9.5	2.55
2100	Red brown	Fairly hard	5.0	5.8	2.51
2200	Brown	Steel hard	6.5	3.0	2.43
2300	Dk. brown	Steel hard	6.5	3.6	2.35
2400	Dk. brown	Steel hard	6.5	2.7	2.35

*Bloating Test:* Negative

*Potential Use:* Low grade brick (color range poor).

SAMPLE: R-397 A

County: Rockingham

*Locality:* Outcrop in a quarry on the northeast side of State Highway 259 approximately three miles west of Cootes Store.

*Description:* The outcrop, which is exposed for a distance of 165 feet, consists of about 15 feet of unweathered olive-green and dark-gray shale overlain by approximately 30 feet of weathered shale. A few thin layers of siltstone are interbedded with the shale. The rocks strike N. 20° E. and dip to the southeast.

*Formation or age:* Brallier shale

*Sampled interval:* Sample across 30 feet of weathered shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.20

*Raw Properties:* Not plastic, short and gritty working, requires 19.0 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Orange buff	Soft crumbly	2.5	14.0	2.62
2000	Orange buff	Soft crumbly	3.5	11.4	2.58
2100	Lt. red brown	Very hard	7.0	6.9	2.52
2200	Red brown	Steel hard	7.5	3.8	2.44
2300	Dk. brown	Steel hard	8.0	2.6	2.37
2400	Dk. brown	Steel hard	8.5	1.8	2.37

*Bloating Test:* Negative

*Potential Use:* Common brick

SAMPLE: R-397B

*Sampled interval:* Composite sample across 13 feet of unweathered shale at locality R-397A.

*Type:* Shale

*Unfired strength:* Below average

*pH:* 8.7

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50 ±	Montmorillonite	3-5
Kaolin	25 ±	Calcite (carbonates)	3 ±
Sericite	10-12	Illite	less than 3
Iron (oxides)	5-8 ±		

*Raw Properties:* Not too plastic, short working, requires 15 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red buff	Soft crumbly	2.5	9.6	2.57
2000	Dull red	Fairly hard	3.5	5.6	2.53
2100	Dk. red	Hard	6.0	2.8	2.42
2200	Dk. red brown	Slightly glazed	4.0	1.4	2.22
2300	Dk. brown	.....	Expanded	1.3	2.04

*Potential Use:* Common red brick and lightweight aggregate.

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>% Abs.</u>	<u>Bulk</u> <u>Sp. Gr.</u>	<u>Lb/ft<sup>3</sup></u>	<u>Remarks</u>
1900	4.9	1.80	112.1	No bloating
2000	4.6	1.38	86.0	No bloating
2100	3.7	0.98	61.1	Good bloating
2200	4.2	0.85	53.0	Good bloating
2300	3.3	0.63	39.2	Overbloating and very sticky

*Firing characteristics:* Expanded material has good strength and low absorption, bloating range is average.

Miniature brick (pressed at 5,000 psi., and fired to 1900°F. with one hour soak):

Approx. Sp. Gr.	2.71	% Shrinkage	2.9
% Absorption	7.2	Hardness	Hard

SAMPLE: R-398

County: Rockingham

*Locality:* Outcrop on the east side of State Highway 259 about 3¼ miles south of the West Virginia State line.

*Description:* An exposure of dark-blue shale, 25 feet in height, extends for a distance of 740 feet along the roadcut. A few thin-bedded layers of dark-gray siltstone are intercalated with shale. The shale and siltstone weather to form rusty-brown fragments. The rocks in the outcrop are folded and faulted.

*Formation or age:* Millboro shale

*Sampled interval:* Composite sample of shale and siltstone from outcrop 25 feet in height.

*Type:* Shale

*Unfired strength:* Low

*pH:* 4.3

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50-60	Iron (oxides)	2±
Sericite	20±	Montmorillonite-chlorite	5-8
Kaolin	10-15	Staurolite	1-2

*Raw Properties:* Fairly plastic, short working, requires 19.0 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. buff	Soft crumbly	2.5	17.0	2.61
2000	Orange buff	Soft crumbly	4.5	12.9	2.58
2100	Lt. red	Very hard	7.5	6.8	2.50
2200	Mottled brown	Steel hard	8.0	2.5	2.27
2300	Mottled gray brown	Steel hard	Expanded	2.5	1.96
2400	Mottled gray brown	Steel hard	Expanded	.....	2.02

*Bloating Test:* Negative

*Potential Use:* Decorative brick

Miniature brick (pressed at 5000 psi., and fired to 1900° F. with one hour soak):

Approx. Sp. Gr.	2.69	% Shrinkage	2.3
% Absorption	7.8	Hardness	Steel hard

SAMPLE: R-1181

County: Rockingham

*Locality:* Outcrop on the northeast side of State Road 798 approximately one mile southeast of Tenth Legion.

*Description:* An exposure of light olive-gray shale and dark-gray calcareous shale, eight feet in height, extends for a distance of 165 feet along the roadcut. These shales weather to form grayish-orange angular fragments. The shale is folded, strikes northwest and generally dips to the southeast. Folded and faulted limestone occurs at the northwestern end of the sampled outcrop.

*Formation or age:* Martinsburg shale

*Sampled interval:* Sample of shale from outcrop eight feet in height

*Type:* Unweathered shale

*Unfired strength:* Low

*pH:* 8.70

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	25-30	Montmorillonite	3-5
Kaolin	3±	Calcite	50-60
Sericite	5-8	Illite	less than 3
Iron (oxides)	1±		

*Raw Properties:* Not plastic, short working, requires 20 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Crumbly soft	3.5	30.7	2.65
2000	Lt. buff	Crumbly soft	4.0	31.3	2.59
2100	Lt. cream	Crumbly soft	4.0	28.8	2.51
2200	.....	.....	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* None (scumming and light color probably due to leaching action of the limestone).

SAMPLE: R-1182

County: Rockingham

*Locality:* Outcrop on the east side of State Road 668 approximately  $1\frac{3}{4}$  miles southeast of the intersection of State Road 668 and State Highway 276.

*Description:* The outcrop consists of about 217 feet of medium-gray, calcareous shale and interbedded layers of fine- to medium-grained, dark-blue sandstone. The shale weathers to form pale and dark yellowish-orange angular fragments and peg-shaped fragments. The rocks strike N.40°E. and dip 85° NW. to 70° SE., and are overlain by about six feet of soil.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 210 feet of shale

*Type:* Shale

*Unfired strength:* Low

*pH:* 7.60

*Raw Properties:* Not too plastic, short and gritty working, requires 24 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Crumbly soft	4.0	19.7	2.62
2000	Lt. red	Fairly hard	4.0	12.7	2.52
2100	Dk. red brown	Steel hard	9.5	2.8	2.39
2200	Dk. brown	.....	9.5	0.7	2.05

*Bloating Test:* Fair expansion (not enough for lightweight aggregate).

*Potential Use:* Common brick and tile

SAMPLE: R-1183A

County: Rockingham

*Locality:* Outcrop on the east side of State Road 674 approximately 1½ miles south of Penn Laird and one quarter of a mile southwest of the junction of State Roads 674 and 655.

*Description:* The outcrop consists of about 230 feet of dark-blue and olive-gray shale and interbedded thin layers of fine-grained brown sandstone. The shale weathers to form dark yellowish-orange and dusky-yellow angular fragments. The rocks strike N.45° to 50° E. and dip 70° to 80° SE., and are weathered to a depth of six feet in the road cut.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 225 feet of shale

*Type:* Unweathered shale                      *Unfired strength:* Low

*pH:* 7.90

*Raw Properties:* Not too plastic, short and gritty working, requires 19 percent water for plasticity, no drying defects, 3.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Crumbly soft	2.0	15.6	2.75
2000	Lt. red	Fairly hard	4.0	10.0	2.66
2100	Very dk. red	Very hard	8.5	5.9	2.62
2200	Dk. red brown	.....	7.5	3.1	2.41
2300	Dk. brown	.....	Expanded	9.8	2.12

*Potential Use:* Common brick and possibly lightweight aggregate

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>% Abs.</u>	<u>Bulk.</u> <u>Sp. Gr.</u>	<u>Lb/ft<sup>3</sup></u>	<u>Remarks</u>
1900	5.7	2.03	126.5	No bloating
2000	4.6	1.62	100.9	No bloating
2100	4.7	1.24	77.3	Good expansion
2200	4.9	0.78	48.6	Overbloomed and sticky
2300	6.2	0.80	49.8	Overbloomed, very sticky, and melting

*Firing Characteristics:* Bloating range rather short, but this sample would probably make acceptable aggregate.

## SAMPLE: R-1183B

*Sampled interval:* Sample of six feet of weathered shale from locality R-1183A.

*Type:* Weathered shale

*Unfired strength:* Low

*pH:* 7.23

*Raw Properties:* Fair plasticity, slightly short and gritty working, requires 23 percent water for plasticity, no drying defects, 3.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Crumbly soft	3.0	20.5	2.73
2000	Lt. red	Fairly hard	4.5	13.7	2.65
2100	Med. red	Hard	8.0	9.5	2.61
2200	Dk. red brown	Very hard	10.5	4.6	2.52
2300	Dk. brown	Slightly glazed	10.5	3.2	2.27
2400	Dk. brown	.....	Expanded	11.6	2.20

*Bloating Test:* Negative

*Potential Use:* Common brick

SAMPLE: R-1184

County: Rockingham

*Locality:* Outcrop on the north side of U. S. Highway 33 approximately  $1\frac{3}{4}$  miles east of Rawley Springs.

*Description:* The outcrop consists of about 70 feet of olive-gray shale and interbedded thin layers of fine-grained, greenish sandstone. The shale weathers to form light-brown angular fragments and peg-shaped fragments. The rocks, which are folded, strike northeast and generally dip to the southeast. The quarry is approximately 42 feet long, 93 feet wide, and up to 12 feet high.

*Formation or age:* Brallier (?) shale

*Sampled interval:* Composite sample across 65 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.6

*Raw Properties:* Fairly plastic, smooth working, requires 22 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Crumbly soft	1.5	15.9	2.47
2000	Reddish buff	Crumbly soft	4.5	11.9	2.46
2100	Dk. red	Very hard	9.5	3.2	2.41
2200	Dk. red brown	Steel hard	10.5	1.4	2.34
2300	Dk. brown	.....	10.5	0.6	2.24
2400	Dk. brown	.....	Expanded	2.0	1.98

*Potential Use:* Brick, tile, and lightweight aggregate

*Bloating Test:*

Temp. °F.	% Abs.	Bulk Sp. Gr.	Lb/ft <sup>3</sup>	Remarks
1900	4.2	2.06	128.3	No bloating
2000	4.3	1.81	112.8	No bloating
2100	4.6	1.42	88.5	Fair bloating
2200	4.5	1.15	71.6	Good bloating
2300	4.0	0.81	50.5	Overbloomed and very sticky

*Firing characteristics:* Very good aggregate material, uniform expansion, long bloating range, and low absorption.

SAMPLE: R-1185

County: Rockingham

*Locality:* Outcrop at the junction of State Roads 820 and 961 about  $2\frac{3}{4}$  miles north of Bergton.

*Description:* The outcrop consists of about 45 feet of moderate olive-brown and light olive-gray shale and interbedded thin layers of olive-green siltstone and sandstone. The shale weathers to form peg-shaped and angular fragments. The rocks strike N.  $20^{\circ}$  E. and dip  $45^{\circ}$  SE.

*Formation or age:* Brallier shale

*Sampled interval:* Composite sample across 40 feet of shale

*Type:* Shale

*Unfired strength:* Low

*pH:* 7.00

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	50-60	Calcite (Carbonates)	2-3
Kaolin	15-20	Montmorillonite	5±
Sericite	12-15	Illite	less than 3
Iron (oxides)	6-8±		

*Raw Properties:* Fairly plastic, smooth working, requires 22 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Crumbly soft	6.5	16.8	2.68
2000	Lt. red	Hard	7.5	9.9	2.66
2100	Dk. red	Very hard	11.5	3.1	2.56
2200	Dk. red brown	Steel hard	12.5	1.8	2.51
2300	Dk. brown	.....	.....	1.6	2.29
2400	Dk. brown	.....	Expanded	9.1	2.31

*Potential Use:* Brick and tile

*Bloating Test:*

Temp. °F.	% Abs.	Bulk Sp. Gr.	Lb/ft <sup>3</sup>	Remarks
1900	5.8	2.14	133.3	No bloating
2000	4.8	1.93	120.2	No bloating
2100	2.9	1.93	120.2	Slight bloating
2200	2.1	1.56	92.7	Slight bloating
2300	4.0	1.29	80.4	Overfired, very sticky

*Firing Characteristics:* No expansion

SAMPLE: R-1186A

County: Rockingham

*Locality:* Outcrop on the west side of State Road 782 approximately 2.8 miles northeast of Edom.

*Description:* The outcrop consists of about 55 feet of dark-gray calcareous shale and interbedded thin layers of fine-grained, brown sandstone. This shale weathers to form grayish-orange and dark yellowish-orange angular fragments. The rocks strike N. 20° to 30° E. and dip 42° to 45° SE. The beds are weathered to an average depth of six feet.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 50 feet of shale.

*Type:* Unweathered shale

*Unfired strength:* Low

*pH:* 8.80

*Raw Properties:* Not too plastic, fairly smooth working, requires 20 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dull pink	Soft crumbly	4.0	31.4	2.75
2000	Very lt. pink	Soft crumbly	2.5	34.1	2.89
2100	.....	(Melted)	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* None (sample high in lime).

## SAMPLE: R-1186B

*Sampled interval:* Six feet of weathered shale at locality R-1186A.

*Type:* Weathered shale

*Unfired strength:* Low

*pH:* 8.70

*Raw Properties:* Plastic, smooth and fatty working, requires 26 percent water for plasticity, no drying defects, 4.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Hard crumbly	4.5	25.5	2.70
2000	Lt. red buff	Hard crumbly	4.5	25.6	2.76
2100	Reddish brown	Fairly hard	4.5	19.6	2.68
2200	.....	(Melted)	.....	.....	.....

*Bloating Test:* Negative

*Potential Use:* None



## SHENANDOAH COUNTY

Samples were collected in Shenandoah County from the Romney shale, Hamilton formation and Hampshire formation of Devonian age, and from the Martinsburg shale of Ordovician age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-657	Martinsburg shale	Common brick
R-658	Martinsburg shale	Lightweight aggregate
R-659	Martinsburg shale	None at present
R-660	Romney shale	Common brick
R-661	Hampshire shale and mudstone	None at present
R-662	Romney shale	None at present
R-663	Devonian shale	Brick and lightweight aggregate
R-664	Martinsburg shale	Lightweight aggregate and brick
R-665	Hamilton shale	Common brick and lightweight aggregate
R-674	Martinsburg shale	Common brick, tile, and lightweight aggregate
R-675	Martinsburg shale	Common brick and lightweight aggregate
R-676	Martinsburg shale	Common brick and lightweight aggregate

SAMPLE: R-657

County: Shenandoah

Locality: Outcrop on the north side of State Highway 55 about one mile southeast of Strasburg.

Description: The outcrop consists of about 40 feet of light olive-gray shale and interbedded layers of brown sandstone. The shale weathers to form pale and dark yellowish-orange angular fragments. The rocks strike N. 50° E. and dip 68° SE., and are overlain by less than two feet of soil.

Formation or age: Martinsburg shale

Sampled interval: Composite sample across 35 feet of shale.

Type: Shale

Unfired strength: Low

pH: 5.1

Composition: X-ray and Petrographic Analysis.

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50-60	Kaolin	15-20
Sericite	15-20	Iron (oxides)	5-8

Raw Properties: Fair plasticity, slightly gritty working, requires 24 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

Fired Properties:

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	5.5	20.6	2.71
2000	Lt. red	Fairly hard	8.5	15.5	2.77
2100	Med. red	Hard	9.5	10.0	2.64
2200	Dk. brown	Steel hard	12.5	4.9	2.47
2300	Dk. brown	Steel hard	11.5	4.3	2.44
2400	Dk. gray brown	.....	Expanded	9.3	2.12

Potential Use: Low grade brick (color not too good and maturing temperature high).

Bloating Test:

Temp. °F.	Bulk Dens.	Lb/ft <sup>3</sup>	% Abs.	Remarks
1900	1.71	106.5	11.0	No bloating
2000	1.80	112.1	6.2	No bloating
2100	1.89	117.7	4.1	Slight bloating
2200	1.73	107.8	4.5	Slight bloating
2300	1.43	88.5	4.9	Slight bloating, very sticky

Firing characteristics: Results indicate that the sample is a mixture of weathered and unweathered shale.

SAMPLE: R-658

County: Shenandoah

*Locality:* Outcrop on the northeast side of State Road 600 about 1½ miles southeast of Maurertown.

*Description:* The outcrop consists of about 310 feet of grayish-olive and dusky-yellow shale and interbedded layers of fine-grained, brown sandstone. The shale weathers to form small peg-shaped, and angular fragments. The rocks strike N. 40° E. and dip 45° SE., and are overlain by up to two feet of sand and gravel.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 300 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.00

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50-60	Montmorillonite	2-3
Sericite	10-15	Iron (oxides)	2-3
Kaolin	10-15		

*Raw Properties:* Not plastic, short and sandy working, requires 23 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	4.5	22.3	2.67
2000	Lt. red	Fairly hard	5.5	15.7	2.60
2100	Lt. red	Hard	6.0	13.8	2.60
2200	Dk. brown	Steel hard	12.5	5.1	2.43
2300	Dk. brown	Steel hard	13.5	3.9	2.40
2400	Dk. gray brown	.....	Expanded	14.9	1.98

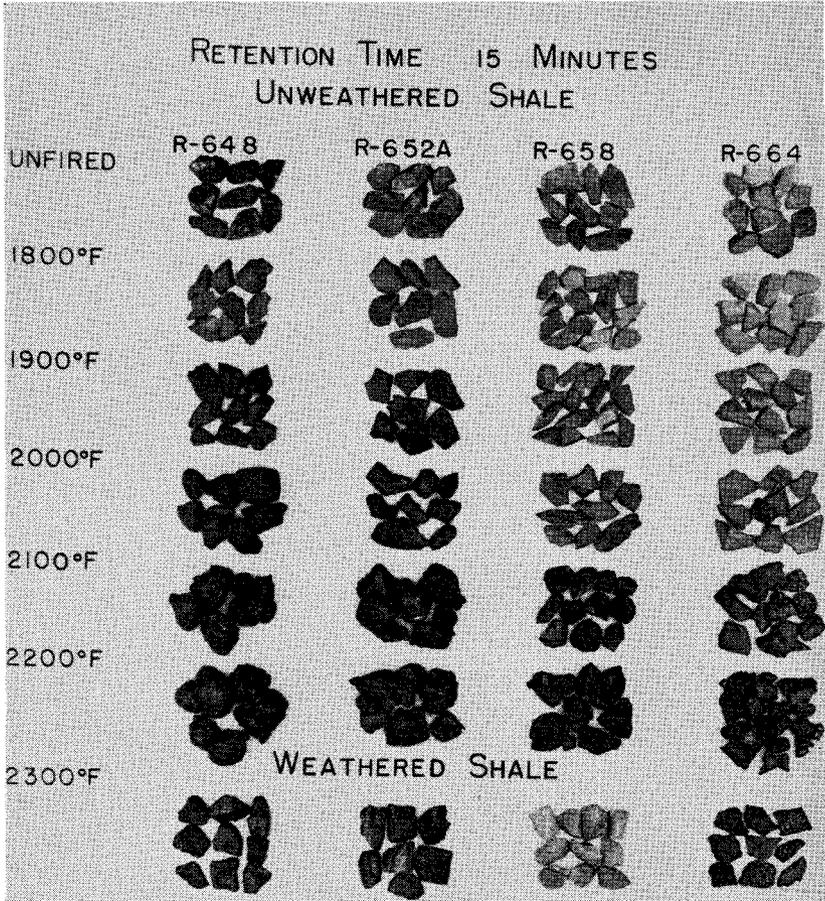
*Potential Use:* Lightweight aggregate (Plate 4, Figure 2)

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>Bulk</u> <u>Dens.</u>	<u>Lb/ft<sup>3</sup></u>	<u>% Abs.</u>	<u>Remarks</u>
1900	1.84	114.6	5.3	No bloating
2000	1.92	119.6	2.4	Slight bloating
2100	1.12	69.8	3.8	Good bloating
2200	0.76	47.3	3.6	Very good bloating
2300	0.74	46.1	3.0	Overbloated, very sticky

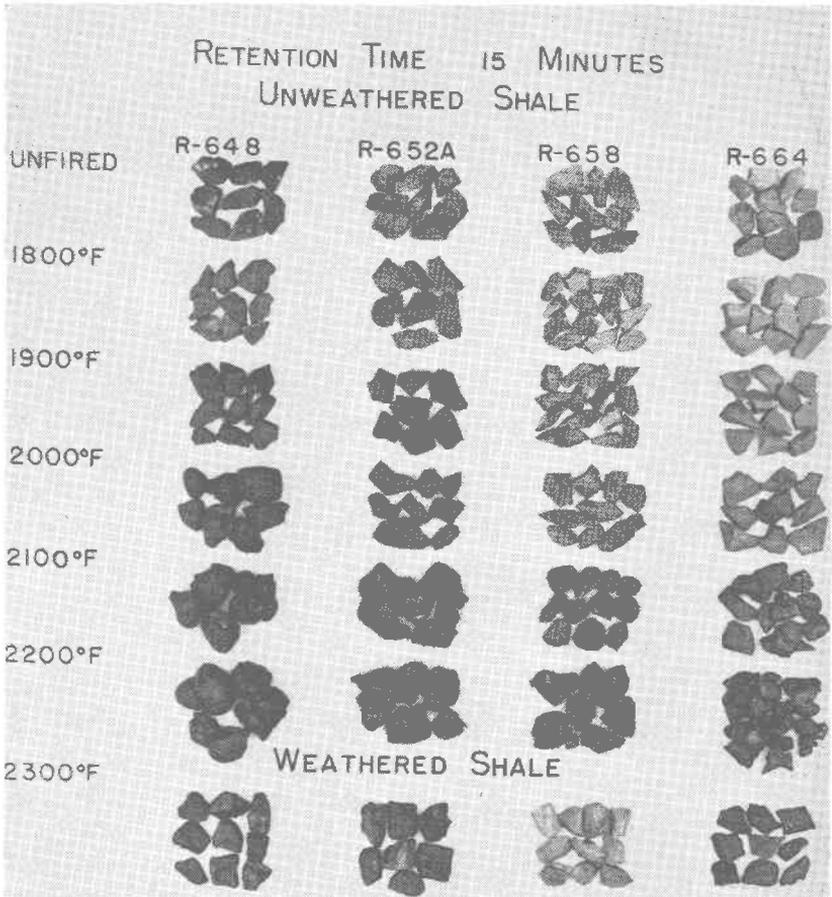
*Firing characteristics:* Excellent aggregate material, expands uniformly, very low percent absorption, good strength, and firing range average.

Plate 4



Four samples of unweathered Martinsburg shale and the resulting expanded aggregate contrasted with expanded aggregate from weathered Martinsburg shale collected at each locality.

Plate 4



Four samples of unweathered Martinsburg shale and the resulting expanded aggregate contrasted with expanded aggregate from weathered Martinsburg shale collected at each locality.

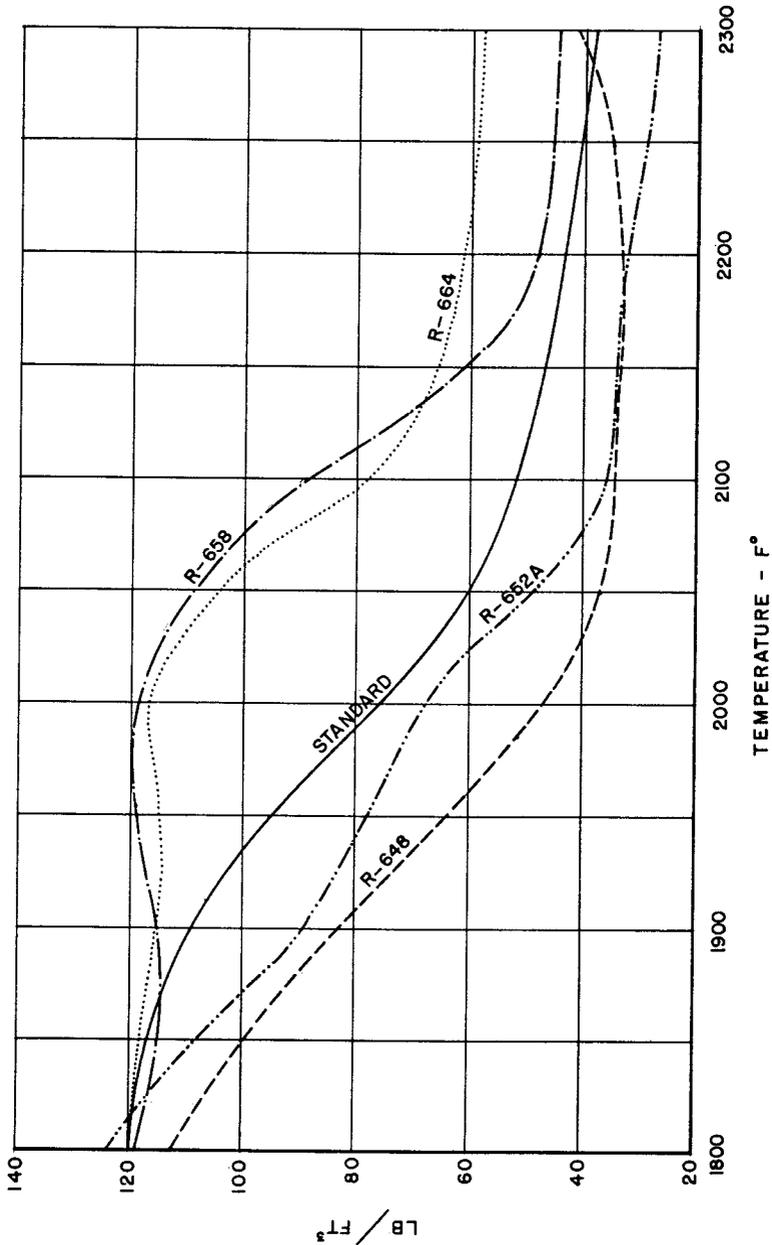


Figure 2. Bloating curves of four samples of Martinsburg shale contrasted with standard bloating curve: R-648, Warren County; R-652A, Frederick County; and R-658 and R-664, Shenandoah County.

SAMPLE: R-659

County: Shenandoah

*Locality:* Outcrop along State Road 600 about two miles northwest of Saumsville.

*Description:* The outcrop consists of about 355 feet of grayish-orange, light-gray, moderate olive-brown and grayish-olive shale and interbedded thin layers of fine-grained, brown sandstone. The rocks strike N. 60° E. and the dip varies from 85° SE. at the southeastern end of the exposure to 80° NW. at the northwestern end.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 350 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.50

*Raw Properties:* Slightly plastic, short and gritty working, requires 22 percent water for plasticity, no drying defects, 2.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	5.0	16.9	2.62
2000	Lt. red	Hard	6.0	10.5	2.54
2100	Med. red	Very hard	8.5	4.8	2.51
2200	Dk. red brown	Steel hard	10.5	3.2	2.38
2300	Dk. brown	.....	Expanded	2.8	2.18
2400	Dk. gray	.....	Expanded	2.5	2.01

*Potential Use:* None

*Bloating Test:*

Temp. °F.	Bulk Dens.	Lb/ft <sup>3</sup>	% Abs.	Remarks
2000	1.81	112.8	3.4	No bloating
2100	1.67	104.0	4.0	Slight bloating
2200	1.57	97.8	4.2	Slight bloating
2300	1.37	85.4	3.5	Overbloating, very sticky

SAMPLE: R-660

County: Shenandoah

*Locality:* Outcrop on the south side of State Road 675 about two miles northeast of Liberty Furnace.

*Description:* The outcrop consists of approximately 215 feet of olive-gray, light olive-gray and moderate olive-brown shale which weathers to form angular and peg-shaped fragments. The rocks strike N. 63° E. and dip 33° SE., and are overlain by less than two feet of soil.

*Formation or age:* Romney shale

*Sampled interval:* Sample across 215 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.20

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	60 ±	Kaolin	8-10
Feldspar	2-3	Iron (oxides)	2-3
Sericite	20 ±	Montmorillonite-chlorite	5 ±

*Raw Properties:* Slightly plastic, short and gritty working, requires 25 percent water for plasticity, no drying defects, 4.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	5.0	16.1	2.47
2000	Lt. red	Fairly hard	5.5	12.4	2.55
2100	Med. red	Hard	9.5	8.9	2.60
2200	Dk. red brown	Steel hard	11.0	3.5	2.40
2300	Dk. brown	Steel hard	11.0	2.9	2.31
2400	Dk. brown	Steel hard	11.0	3.6	2.25

*Bloating Test:* Negative

*Potential Use:* Might make common brick at 2150° F.

SAMPLE: R-661

County: Shenandoah

*Locality:* Outcrop on the northeast side of State Road 703 about 1¼ miles northwest of Conicville.

*Description:* The outcrop consists of about 43 feet of grayish-red shale, dark reddish-brown mudstone, and interbedded layers of fine-grained, red and olive-green sandstone. A few of the sandstone beds appear to be lenticular and show cross-bedding. The rocks strike N. 50° E. and dip 15° SE.

*Formation or age:* Hampshire (Catskill) formation (?)

*Sampled interval:* Composite sample across 40 feet of shale and mudstone.

*Type:* Shale and mudstone

*Unfired strength:* Low

*pH:* 6.30

*Raw Properties:* Not plastic, short and gritty working, requires 15 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	1.0	14.1	2.57
2000	Lt. red	Fairly hard	1.0	11.7	2.56
2100	Med. red	Hard	1.0	10.9	2.56
2200	Dk. red brown	Very hard	5.5	6.0	2.41
2300	Dk. brown	Steel hard	5.5	3.4	2.23
2400	Dk. brown	Steel hard	5.5	4.5	2.36

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-662

County: Shenandoah

*Locality:* Outcrop on the northeast side of State Road 720 about half a mile southeast of the junction of State Roads 717 and 720, and about  $2\frac{1}{4}$  miles southwest of Jerome.

*Description:* An exposure of weathered olive-gray and light olive-gray shale, 20 feet in height, extends for a distance of 318 feet along the roadcut. Medium-bedded, fine-grained, dark-blue sandstone is interbedded with the shale.

*Formation or age:* Romney (?) shale

*Sampled interval:* Composite sample of shale from outcrop 20 feet in height.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.35

*Raw Properties:* Not plastic, short and gritty working, requires 20 percent water for plasticity, no drying defects, 0.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	1.0	22.5	2.56
2000	Lt. red	Soft crumbly	1.0	19.3	2.50
2100	Med. red	Soft crumbly	3.0	17.8	2.49
2200	Med. red	Hard	6.0	7.4	2.28
2300	Dk. red brown	Very hard	9.0	7.1	2.36
2400	Dk. brown	Steel hard	9.0	4.8	2.21

*Bloating Test:* Negative

*Potential Use:* None

SAMPLE: R-663

County: Shenandoah

*Locality:* Outcrop in a small quarry on the east side of State Road 612 approximately 3½ miles southwest of Mill.

*Description:* The outcrop consists of 40 feet of dark-gray and olive-gray fissile shale which weathers to form small peg-shaped and angular fragments. The rocks strike N. 35° E. and dip 85° SE.

*Formation or age:* Devonian

*Sampled interval:* Sample across 40 feet of shale.

*Type:* Shale

*Unfired strength:* Slightly below

*pH:* 4.90

average

*Raw Properties:* Fair plasticity, short and gritty working, requires 18 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	4.5	15.2	2.66
2000	Lt. red	Fairly hard	5.0	11.6	2.62
2100	Med. red brown	Very hard	5.5	8.0	2.61
2200	Dk. red	Steel hard	7.0	6.9	2.44
2300	Dk. brown	Steel hard	7.0	4.9	2.18
2400	Dk. gray brown	.....	Expanded	11.2	2.03

*Potential Use:* Good red brick at 2100° F. and lightweight aggregate.

*Bloating Test:*

Temp. °F.	Bulk Dens.	Lb/ft <sup>3</sup>	% Abs.	Remarks
1900	1.51	94.1	7.3	No bloating
2000	1.32	82.2	7.8	Fair bloating
2100	0.94	58.6	9.6	Good bloating
2200	0.90	56.1	12.1	Good bloating, slightly sticky
2300	0.71	44.2	13.5	Overbloating, very sticky



Outcrop of the Martinsburg shale (Sample R-664) on the northeast side of State Road 670 about one mile southeast of Woodstock, Shenandoah County.



Outcrop of the Martinsburg shale (Sample R-664) on the northeast side of State Road 670 about one mile southeast of Woodstock, Shenandoah County.

SAMPLE: R-664

County: Shenandoah

*Locality:* Outcrop on the northeast side of State Road 670 about one mile southeast of Woodstock. (Plate 5)

*Description:* An exposure of light olive-gray and dark-gray shale and olive-green sandstone. 10 feet in height, extends for a distance of 560 feet along the roadcut. The rocks strike N. 30° E. and generally dip to the southeast.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample of shale from an outcrop 10 feet in height.

*Type:* Shale

*Unfired strength:* Below average

*pH:* 5.50

*Raw Properties:* Fair plasticity, short and gritty working, requires 22 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	4.0	19.3	2.66
2000	Med. red	Very hard	6.0	11.6	2.61
2100	Med. red brown	Steel hard	11.0	4.9	2.51
2200	Dk. red brown	.....	Expanded	5.4	2.12
2400	Dk. gray brown	.....	Expanded	8.4	2.02

*Potential Use:* Lightweight aggregate and brick (Plate 4, Figure 2)

*Bloating Test:*

Temp. °F.	Bulk Dens.	Lb/ft <sup>3</sup>	% Abs.	Remarks
1900	1.86	115.9	12.9	No bloating
2000	1.88	117.1	4.2	Slight expansion
2100	1.24	77.3	4.8	Fair bloating
2200	0.98	61.0	5.3	Good bloating, very sticky
2300	0.94	58.6	6.0	Overbloating, very sticky

*Firing characteristics:* Fair aggregate material, percent absorption very low, firing range very short.

SAMPLE: R-665

County: Shenandoah

*Locality:* Outcrop on the west side of State Road 678 about 1½ miles northeast of Seven Fountains P. O.

*Description:* The outcrop consists of about 60 feet of olive-gray shale which weathers to form small peg-shaped fragments. The rocks appear to strike N. 30° E. and dip 50° SE.

*Formation or age:* Hamilton formation

*Sampled interval:* Sample across 60 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.65

*Raw Properties:* Slightly plastic, short and gritty working, requires 24 percent water for plasticity, no drying defects, 2.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	4.0	15.8	2.51
2000	Med. red	Hard	9.0	5.2	2.46
2100	Dk. red	Very hard	10.0	3.8	2.40
2200	Med. brown	Steel hard	11.0	1.0	2.34
2300	Med. brown	Steel hard	11.0	0.6	2.30
2400	Dk. brown	.....	Expanded	0.7	1.65

*Potential Use:* Common brick and lightweight aggregate.

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>Bulk</u> <u>Dens.</u>	<u>Lb/ft<sup>3</sup></u>	<u>% Abs.</u>	<u>Remarks</u>
1900	1.58	98.4	7.8	No bloating
2000	1.32	82.2	7.6	Fair bloating
2100	0.89	55.4	6.2	Excellent bloating
2200	0.87	54.2	7.2	Excellent bloating, slightly sticky
2300	0.77	47.8	5.2	Overbloating, very sticky

*Firing Characteristics:* Good aggregate material, expansion uniform, percent absorption low, and firing range average.

SAMPLE: R-674

County: Shenandoah

*Locality:* Outcrop along State Road 758 approximately 2½ miles east of Woodstock.

*Description:* The outcrop consists of approximately 135 feet of light olive-gray shale and interbedded layers of olive-green and yellowish-orange sandstone. The shale weathers to form angular fragments. The rocks strike N. 35° E. and generally dip 75° SE., the dip changes to northwest at the northern end of the roadcut where a minor flexure is exposed.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across about 130 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.2

*Raw Properties:* Short and gritty working, requires 25 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	5.5	19.1	2.79
2000	Lt. red	Fairly hard	9.5	9.9	2.72
2100	Dk. red	Very hard	12.5	5.4	2.62
2200	Dk. red brown	Steel hard	13.5	2.7	2.57
2300	Dk. brown	.....	13.5	2.0	2.47
2400	Dk. brown	.....	Expanded	3.8	2.34

*Bloating Test:* Unweathered material shows good bloating.

*Potential Use:* Common brick, tile, and lightweight aggregate.

SAMPLE: R-675

County: Shenandoah

*Locality:* Outcrop on the west side of State Road 675 approximately 2½ miles southeast of Edinburg.

*Description:* The outcrop consists of approximately 235 feet of dark-gray and light olive-gray shale and interbedded thin layers of fine-grained, yellowish-orange and dark-gray sandstone. The shale weathers to form peg-shaped and angular fragments. The rocks strike N. 40° E. and dip 30° SE.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 230 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.70

*Raw Properties:* Short and gritty working, requires 27 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Reddish buff	Soft crumbly	5.5	17.7	2.80
2000	Dk. red	Fairly hard	9.5	9.2	2.72
2100	Dk. red brown	Very hard	11.0	5.8	2.63
2200	Dk. brown	.....	11.0	4.0	2.34
2300	Dk. brown	.....	Expanded	10.5	2.11
2400	Dk. brown	.....	Expanded	14.6	2.10

*Potential Use:* Common brick and lightweight aggregate.

*Bloating Test:*

Temp. °F.	Bulk Dens.	Lb/ft <sup>3</sup>	% Abs.	Remarks
1900	1.90	118.4	6.8	No bloating
2000	1.63	101.5	4.8	No bloating
2100	1.01	62.9	6.0	Excellent bloating
2200	1.05	65.4	3.0	Excellent bloating, fairly sticky

*Firing characteristics:* The unweathered shale shows good expansion; aggregate very strong with low absorption.

SAMPLE: R-676

County: Shenandoah

*Locality:* Outcrop in a small quarry on the north side of State Road 620 approximately a quarter of a mile southeast of Alpine.

*Description:* The outcrop consists of about 105 feet of olive-gray shale and interbedded thin layers of fine-grained, light-brown, cross bedded sandstone. The shale weathers to form grayish-orange angular fragments. The rocks strike N. 20° E. and dip 45° SE., and are overlain by one foot of soil.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 100 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.15

*Raw Properties:* Short and gritty working, requires 24 percent water for plasticity, no drying defects, 5.0 percent drying shrinkage.

*Fired Properties:*

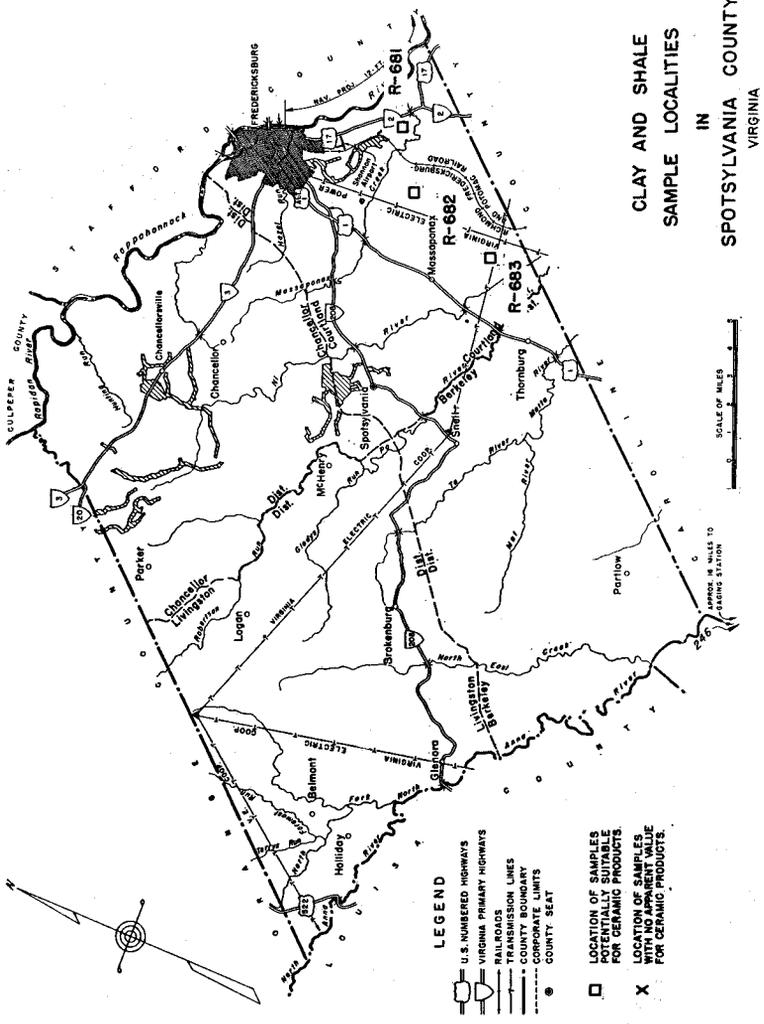
Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	5.5	18.3	2.79
2000	Dk. red	Fairly hard	6.5	11.7	2.70
2100	Dk. red brown	Hard	10.0	7.0	2.62
2200	Dk. brown	.....	Expanded	4.3	2.45
2300	Dk. brown	.....	Expanded	6.6	2.19
2400	Dk. brown	.....	Expanded	9.6	2.15

*Potential Use:* Common brick and lightweight aggregate.

*Bloating Test:*

Temp. °F.	Bulk Dens.	Lb/ft <sup>3</sup>	% Abs.	Remarks
1900	1.92	119.6	5.2	No bloating
2000	1.52	94.7	4.6	No bloating
2100	0.98	61.1	5.4	Excellent bloating
2200	0.81	50.4	4.0	Excellent bloating, sticky

*Firing characteristics:* Unweathered shale shows good bloating.



Location Map of Spotsylvania County

## SPOTSYLVANIA COUNTY

Samples were collected in Spotsylvania County from clay of Tertiary age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-681	Tertiary (?) clay	Common brick
R-682	Tertiary (?) clay	Common brick
R-683	Tertiary (?) clay	Could be used to improve plasticity of other clay materials

SAMPLE: R-681

County: Spotsylvania

*Locality:* Outcrop along State Road 609 approximately five miles southeast of Fredericksburg.

*Description:* An outcrop of dark yellowish-orange and light-gray clay, seven feet in height, extends for a distance of 210 feet along the roadcut.

*Formation or age:* Tertiary (?)

*Sampled interval:* Sample of clay from outcrop seven feet in height.

*Type:* Clay

*Unfired strength:* Average

*pH:* 3.89

*Raw Properties:* Plastic, long and gritty working, requires 33 percent water for plasticity, no drying defects, 6.0 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. reddish buff	Soft crumbly	7.5	21.2	2.63
2000	Red	Soft crumbly	10.0	15.7	2.61
2100	Dk. red	Soft crumbly	10.5	14.9	2.62
2200	Dk. red brown	Fairly hard	11.5	12.2	2.60
2300	Dk. red brown	Hard	14.0	10.0	2.56
2400	Black brown	Very hard	15.5	4.1	2.38

*Bloating Test:* Negative

*Potential Use:* Common brick

SAMPLE: R-682

County: Spotsylvania

*Locality:* Outcrop along State Road 608 about 3¼ miles northeast of Massaponax.

*Description:* An exposure of dark yellowish-orange and light-gray clay, one foot in height, extends for a distance of 312 feet along the roadcut. Five feet of clay was encountered in an auger hole. The clay has less than four feet of sandy overburden.

*Formation or age:* Tertiary (?)

*Sampled interval:* Six feet of clay

*Type:* Clay  
*pH:* 4.00

*Unfired strength:* Above average

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz	70 ±	Kaolin	5-10
Feldspar	1-2	Iron (oxides)	1-2
Sericite	10 ±	Montmorillonite-chlorite	5-8

*Raw Properties:* Plastic, slightly gritty and long working, requires 42 percent water for plasticity, no drying defects, 7.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Soft crumbly	9.5	20.6	2.68
2000	Dk. buff	Fairly hard	13.5	10.7	2.56
2100	Red	Hard	14.5	8.2	2.55
2200	Dk. red brown	Very hard	16.0	5.0	2.47
2300	Dk. red gray	Very hard	16.0	4.0	2.46
2400	Dull gray	.....	Expanded	9.2	2.26

*Bloating Test:* Negative

*Potential Use:* Common brick (could be used to improve workability of other materials).

SAMPLE: R-683

County: Spotsylvania

*Locality:* Outcrop on State Road 607 approximately 2½ miles south-east of Massaponax.

*Description:* Dark yellowish-orange and light-gray clay is exposed into outcrops which are 312 feet long and 150 feet long. These exposures are separated by a covered interval of 150 feet. Clay was encountered in an auger hole drilled in the covered interval. The exposure has a maximum height of about eight feet and is covered by less than eight feet of sandy overburden.

*Formation or age:* Tertiary (?)

*Sampled interval:* Composite sample of eight feet of clay.

*Type:* Clay

*Unfired strength:* Above average

*pH:* 3.94

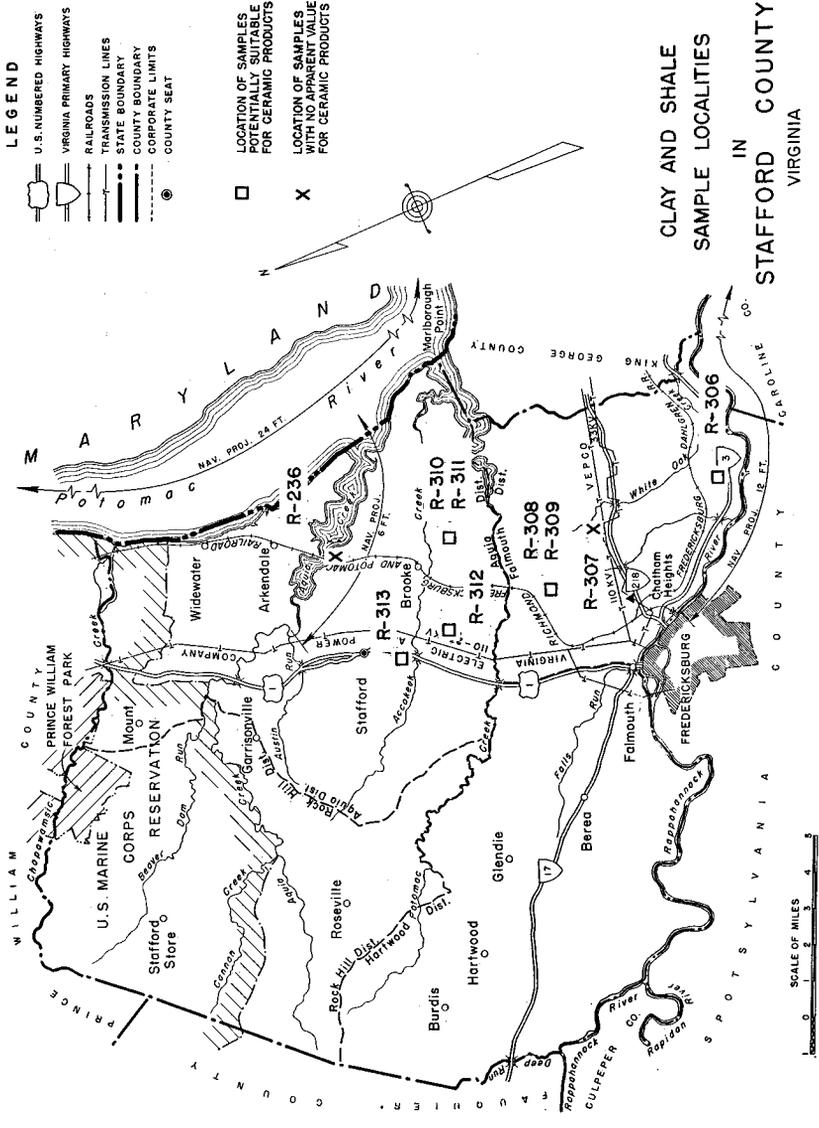
*Raw Properties:* Plastic, long working, requires 44 percent water for plasticity, no drying defects, 7.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	8.5	24.4	2.63
2000	Orange buff	Soft crumbly	10.5	20.7	2.72
2100	Med. red	Fairly hard	13.5	14.5	2.65
2200	Dk. red	Hard	16.5	8.5	2.63
2300	Red gray	Very hard	19.0	4.1	2.45
2400	Gray brown	.....	Expanded	9.4	2.14

*Bloating Test:* Negative

*Potential Use:* None (shrinkage is too high for clay to be used alone could be used to increase plasticity of other materials).



Location Map of Stafford County

## STAFFORD COUNTY

Samples were collected in Stafford County from clay of Cretaceous age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-236	Cretaceous clay	None at present
R-306	Cretaceous clay	In low heat duty fire bricks
R-307	Cretaceous clay	None at present
R-308	Cretaceous clay	In low heat duty fire bricks
R-309	Cretaceous clay	In low heat duty fire bricks
R-310	Cretaceous clay	In low heat duty fire bricks
R-311	Cretaceous clay	In low heat duty fire bricks
R-312	Cretaceous clay	Common brick and tile
R-313	Cretaceous clay	Brick and tile

SAMPLE: R-236

County: Stafford

*Locality:* Outcrop along the Richmond, Fredericksburg and Potomac Railroad, just south of Aquia Station.

*Description:* An exposure of light-brown clay, 12 feet in height, extends for a distance of 420 feet along the cut. This clay weathers to form rectangular fragments and contains some lignite. The clay has less than 15 feet of sandy overburden and is underlain by sand and gravel.

*Formation or age:* Cretaceous

*Sampled interval:* Sample of clay from exposure 12 feet in height.

*Type:* Clay

*Unfired strength:* Low

*pH:* 4.50

*Raw Properties:* Fairly plastic, smooth and fatty working, requires 48 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. tan	Soft crumbly	6.0	34.4	2.64
2000	Med. tan	Soft crumbly	10.0	24.5	2.62
2100	Dk. tan	Soft crumbly	14.0	18.6	2.59
2200	Brown	Fairly hard	15.5	12.3	2.57
2300	Gray brown	Very hard	20.0	2.9	2.42
2400	Med. gray	Very hard	20.0	7.2	2.55

*Bloating Test:* Negative

*Potential Use:* None (fired specimen showed scumming).

SAMPLE: R-306

County: Stafford

*Locality:* Outcrop along State Highway 3 approximately one mile west of Butzner Corner.

*Description:* The exposure, which is 13 feet high, consists of red and gray clay weathering to form small rectangular plates. The clay is underlain by yellowish-brown sand and is overlain by up to 12 feet of sand and gravel.

*Formation or age:* Cretaceous

*Sampled interval:* Sample of clay from exposure 13 feet in height.

*Type:* Clay

*Unfired strength:* Above average

*pH:* 4.1

*Composition:* X-ray and Petrographic Analysis

	Approx. %		Approx. %
Quartz, large grain	30±	Glass (isotropic)	10-15
Montmorillonite (in glass)	25-35	Muscovite	5
Kaolin	15-20		

*Raw Properties:* Fairly plastic, smooth and slightly gritty working, requires 27 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Buff	Soft crumbly	6.0	20.9	2.59
2000	Buff	Soft crumbly	8.5	18.8	2.59
2100	Dk. buff	Fairly hard	10.5	12.3	2.54
2200	Lt. red brown	Hard	14.0	7.4	2.44
2300	Med. red brown	Very hard	14.5	4.1	2.41
2400	Lt. red gray	Steel hard	15.0	2.2	2.34

*Bloating Test:* Negative

*Potential Use:* The fusion point indicates this clay is suitable for low duty fire brick. (Pyrometric cone equivalent between cones 23 to 26—2876° F. to 2903° F.)

SAMPLE: R-307

County: Stafford

*Locality:* Outcrop along State Road 669 about half a mile northeast of Sullivan.

*Description:* An exposure of light-gray, yellowish-brown, and reddish-brown clay, five feet in height, extends for a distance of 105 feet along the roadcut.

*Formation or age:* Cretaceous

*Sampled interval:* Sample of clay from exposure five feet in height.

*Type:* Clay

*Unfired strength:* Average

*pH:* 4.40

*Raw Properties:* Fair plasticity, smooth and gritty working, requires 30 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	5.5	18.8	2.67
2000	Dk. buff	Soft crumbly	7.0	17.7	2.69
2100	Red	Soft crumbly	8.0	15.1	2.67
2200	Dk. red	Fairly hard	9.5	13.4	2.63
2300	Dk. red brown	Fairly hard	10.0	10.8	2.59
2400	Red gray	Hard	11.0	7.8	2.56

*Bloating Test:* Negative

*Potential Use:* None

## Plate 6



Outcrop of Cretaceous (?) clay (Samples R-308 and R-309) along State Road 608 approximately one mile south of Daffins Crossing, Stafford County.

Plate 6



Outcrop of Cretaceous (?) clay (Samples R-308 and R-309) along State Road 608 approximately one mile south of Daffins Crossing, Stafford County.

SAMPLE: R-308

County: Stafford

*Locality:* Outcrop along State Road 608 approximately one mile south of Daffins Crossing. (Plate 6)

*Description:* The outcrop consists of 15 feet of light-gray and yellowish-brown clay (Sample R-308), separated by seven feet of reddish-brown clay (Sample R-309). The light-gray and yellowish-brown clay contains thin laminae of sand cemented by iron oxide and weathers to form rectangular plates. The reddish-brown clay contains some carbonaceous material.

*Formation or age:* Cretaceous

*Sampled interval:* Fifteen feet of light-gray and yellowish-brown clay.

*Type:* Clay

*Unfired strength:* Average

*pH:* 4.3

*Raw Properties:* Fair plasticity, smooth and slightly gritty working, requires 38 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Pink buff	Soft crumbly	5.0	25.7	2.59
2000	Pink buff	Soft crumbly	7.5	31.4	2.61
2100	Pink buff	Soft crumbly	9.5	18.1	2.58
2200	Pinkish tan	Fairly hard	11.5	12.2	2.51
2300	Pinkish tan	Hard	12.0	11.2	2.50
2400	Pinkish gray	Very Hard	15.5	5.1	2.48

*Bloating Test:* Negative

*Potential Use:* The fusion point indicates this clay is suitable for low duty fire brick. (Pyrometric cone equivalent slightly below cone 23—2876° F.) See Plate 7.

SAMPLE: R-309

County: Stafford

*Sampled interval:* Seven feet of reddish-brown clay from locality R-308.

*Type:* Clay*Unfired strength:* Average*pH:* 4.4

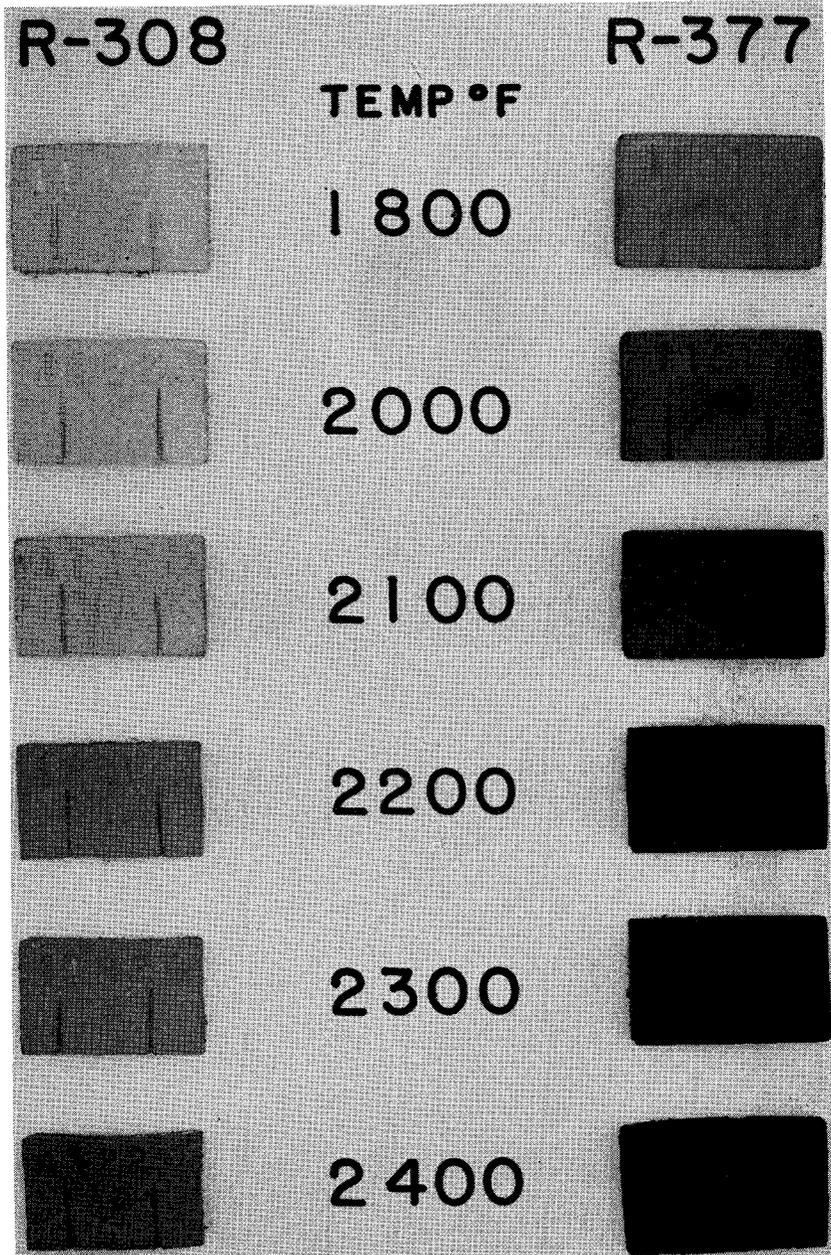
*Raw Properties:* Fair plasticity, smooth and slightly gritty working, requires 38 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

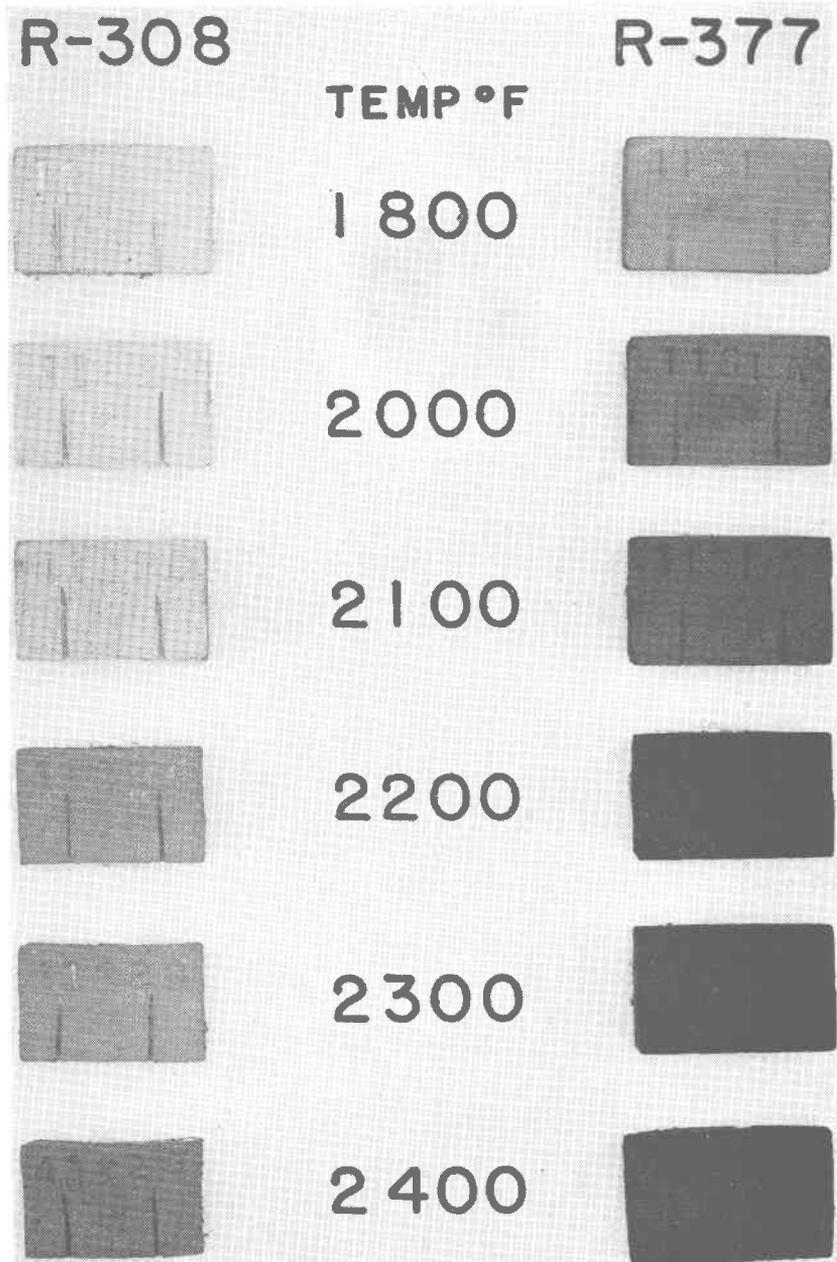
<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	5.5	28.3	2.68
2000	Buff	Soft crumbly	9.5	24.5	2.73
2100	Tan buff	Fairly hard	10.0	18.5	2.70
2200	Red brown	Hard	14.0	12.3	2.59
2300	Red brown	Hard	14.0	12.0	2.60
2400	Red gray	Steel hard	15.5	4.2	2.49

*Bloating Test:* Negative

*Potential Use:* The fusion point indicates this clay is suitable for low duty fire brick. (Pyrometric cone equivalent slightly below cone 23—2876° F.)



Test briquettes from Cretaceous clay (Sample R-308) and from the Martinsburg shale of Ordovician age (Sample R-377).



Test briquettes from Cretaceous clay (Sample R-308) and from the Martinsburg shale of Ordovician age (Sample R-377).

SAMPLE: R-310

County: Stafford

*Locality:* Outcrop along State Road 609 about three-quarters of a mile south of Fitters Corner.

*Description:* The outcrop consists of 12 feet of yellowish-brown and light-gray clay (Sample R-310), separated by 11 feet of reddish-brown clay (Sample R-311). These clays contain thin discontinuous stringers and mottled zones of sand cemented by iron oxide. The clay is underlain by gray sand and has less than 7 feet of sandy overburden.

*Formation or age:* Cretaceous

*Sampled interval:* Twelve feet of clay

*Type:* Clay

*Unfired strength:* Above average

*pH:* 4.3

*Raw Properties:* Plastic smooth working, requires 40 percent water for plasticity, no drying defects, 6.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Lt. buff	Soft crumbly	9.0	25.0	2.45
2000	Lt. buff	Soft crumbly	9.0	24.2	2.47
2100	Lt. buff	Soft crumbly	12.5	15.7	2.45
2200	Lt. tan	Fairly hard	15.0	10.2	2.42
2300	Lt. tan	Hard	15.5	8.1	2.40
2400	Tan	Steel hard	20.0	4.7	2.36

*Bloating Test:* Negative

*Potential Use:* The fusion point indicates this clay is suitable for low duty fire brick. (Pyrometric cone equivalent between cones 23 to 26—2876° F. to 2903° F.)

SAMPLE: R-311

*County:* Stafford

*Sampled interval:* Eleven feet of clay from same locality as sample R-310.

*Type:* Clay*pH:* 4.5

*Raw Properties:* Plastic, smooth working, requires 27 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Lt. red buff	Soft crumbly	7.0	25.5	2.55
2000	Lt. red buff	Soft crumbly	8.5	23.7	2.61
2100	Lt. red buff	Soft crumbly	14.0	13.8	2.56
2200	Med. red	Hard	15.5	10.0	2.53
2300	Med. red	Very hard	16.0	8.1	2.48
2400	Dk. red brown	Steel hard	16.0	4.1	2.41

*Bloating Test:* Negative

*Potential Use:* The fusion point indicates this clay is suitable for low duty fire brick. (Pyrometric cone equivalent between cones 23 to 26—2876° F. to 2903° F.)

SAMPLE: R-312                      County: Stafford

*Locality:* Outcrop along State Road 628 about two miles southeast of Pine Grove.

*Description:* An exposure of light-gray, dark reddish-brown, and dark yellowish-orange clay, 10 feet in height, extends for a distance of 225 feet along the roadcut. The clay appears to thin at the eastern end of the exposure.

*Formation or age:* Cretaceous

*Sampled interval:* Sample of clay from outcrop 10 feet in height.

*Type:* Clay                      *Unfired strength:* Above average  
*pH:* 5.35

*Raw Properties:* Very plastic, smooth working, requires 28 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	8.5	20.2	2.61
2000	Dk. buff	Soft crumbly	14.0	12.0	2.71
2100	Red	Very hard	15.0	9.7	2.65
2200	Dk. red brown	Steel hard	15.0	7.5	2.57
2300	Dk. brown	Steel hard	16.0	5.2	2.53
2400	Dk. brown	Steel hard	16.0	4.2	2.51

*Bloating Test:* Negative

*Potential Use:* Common brick and tile

SAMPLE: R-313

County: Stafford

*Locality:* Outcrop along U. S. Highway 1 about 1½ miles southwest of Stafford Court House.

*Description:* An exposure of light-gray, dark reddish-brown, and dark yellowish-orange clay, 12 feet in height, extends for a distance of 500 feet on both sides of the highway. This clay is covered by up to five feet of sand and gravel.

*Formation or age:* Cretaceous

*Sampled interval:* Sample of clay from exposure 12 feet in height.

*Type:* Clay

*Unfired strength:* Above average

*pH:* 4.85

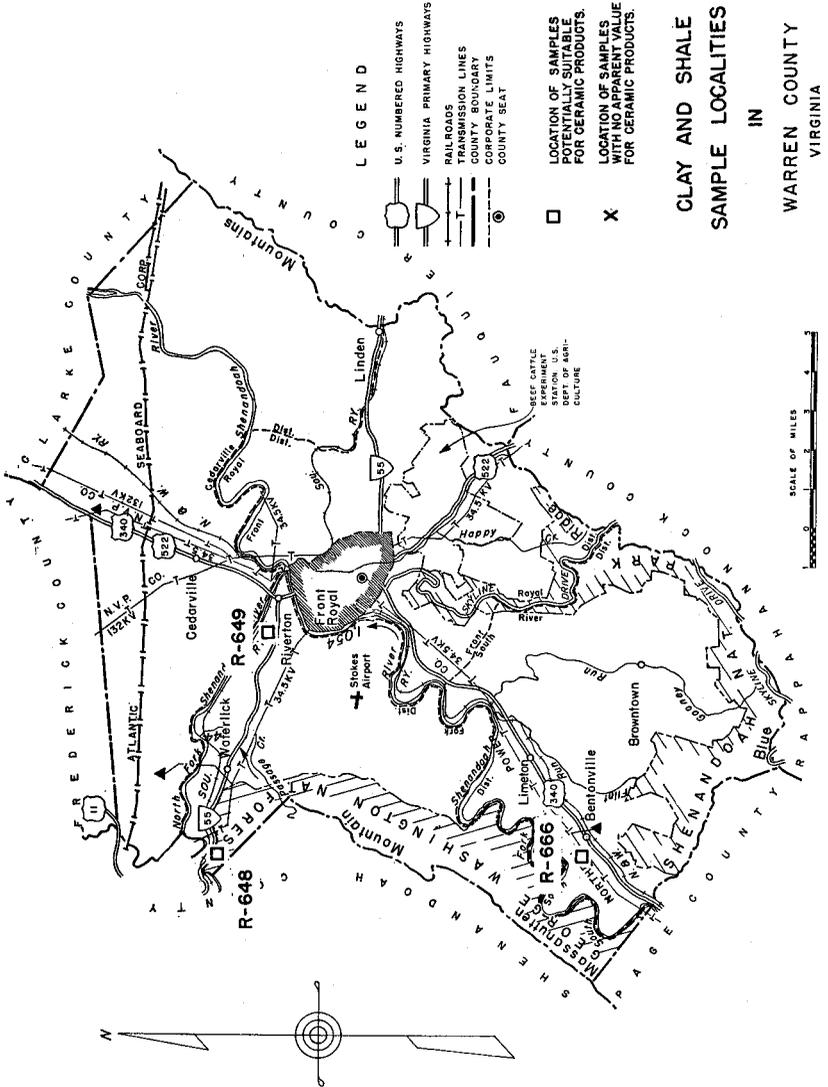
*Raw Properties:* Plastic, smooth working, requires 30 percent water for plasticity, no drying defects, 5.5 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Orange buff	Soft crumbly	6.5	20.2	2.64
2000	Orange buff	Soft crumbly	11.0	14.9	2.64
2100	Orange buff	Fairly hard	14.5	11.6	2.59
2200	Mottled brown	Steel hard	15.0	6.4	2.50
2300	Dk. brown	Steel hard	15.5	4.0	2.54
2400	Dk. brown	Steel hard	15.5	2.7	2.54

*Bloating Test:* Negative

*Potential Use:* Could be used for making brick or tile if mixed with another clay to get uniform color.



Location Map of Warren County

## WARREN COUNTY

Samples were collected in Warren County from the Martinsburg shale of Ordovician age. Laboratory testing indicates the following potential uses for the raw materials sampled:

<u>Sample</u>	<u>Material</u>	<u>Potential use</u>
R-648	Martinsburg shale	Common brick and lightweight aggregate
R-649	Martinsburg shale	Common brick and tile
R-666	Martinsburg shale	Common brick

SAMPLE: R-648

County: Warren

*Locality:* Outcrop on the south side of State Highway 55 approximately  $2\frac{1}{4}$  miles northwest of Waterlick. (Plate 8)

*Description:* The outcrop, which is exposed for a distance of 360 feet, consists of 110 feet of dark-gray and olive-gray shale and interbedded layers of fine-grained, dark-gray sandstone. The shale weathers to form peg-shaped and angular fragments. The rocks strike N. 65° E. and dip 35° to 40° SE.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 105 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 6.90

*Composition:* X-ray and Petrographic Analysis

	<u>Approx. %</u>		<u>Approx. %</u>
Quartz	50 ±	Montmorillonite	10-15
Sericite	5-8	Iron (oxides)	3-5
Chlorite	15-20		

*Raw Properties:* Not plastic, short working, requires 17 percent water for plasticity, no drying defects, no drying shrinkage.

*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Dk. buff	Soft crumbly	3.0	12.9	2.69
2000	Med. red	Fairly hard	5.0	6.9	2.59
2100	Med. red brown	Steel hard	5.0	3.4	2.31
2200	Brown	.....	Expanded	.....	.....
2300	Brown	.....	Expanded	.....	.....
2400	Brown	.....	Expanded	.....	.....

*Potential Use:* Common brick and lightweight aggregate. (Plate 4, Figure 2)

*Bloating Test:*

<u>Temp.</u> <u>°F.</u>	<u>% Abs.</u>	<u>Bulk</u> <u>Sp. Gr.</u>	<u>Lb/ft<sup>3</sup></u>	<u>Remarks</u>
1800	5.8	1.80	112.1	No bloating
1900	4.9	1.32	82.2	Fair bloating
2000	4.8	0.72	44.8	Excellent bloating
2100	5.3	0.55	34.3	Overbloomed, slight sticking
2200	8.4	0.53	33.0	Overbloomed, fragile, very sticky
2300	8.3	0.66	41.0	Overbloomed, slagging

*Firing Characteristics:* Good bloating range, excellent material.

## Plate 8



Outcrop of the Martinsburg shale (Sample R-648) on the south side of State Highway 55 approximately  $2\frac{1}{4}$  miles northwest of Waterlick, Warren County.

## Plate 8



Outcrop of the Martinsburg shale (Sample R-648) on the south side of State Highway 55 approximately  $\frac{2}{4}$  miles northwest of Waterlick, Warren County.

SAMPLE: R-649

County: Warren

*Locality:* Outcrop on the north side of State Highway 55 about one mile west of Riverton.

*Description:* The outcrop consists of 233 feet of pale and dark yellowish-orange shale and interbedded layers of fine-grained sandstone. The shale weathers to form small angular and peg-shaped fragments. The rocks strike N. 15° E. and dip 85° NW.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 225 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 4.80

*Raw Properties:* Fair plasticity, slightly short working, requires 29 percent water for plasticity, no drying defects, 3.5 percent drying shrinkage.

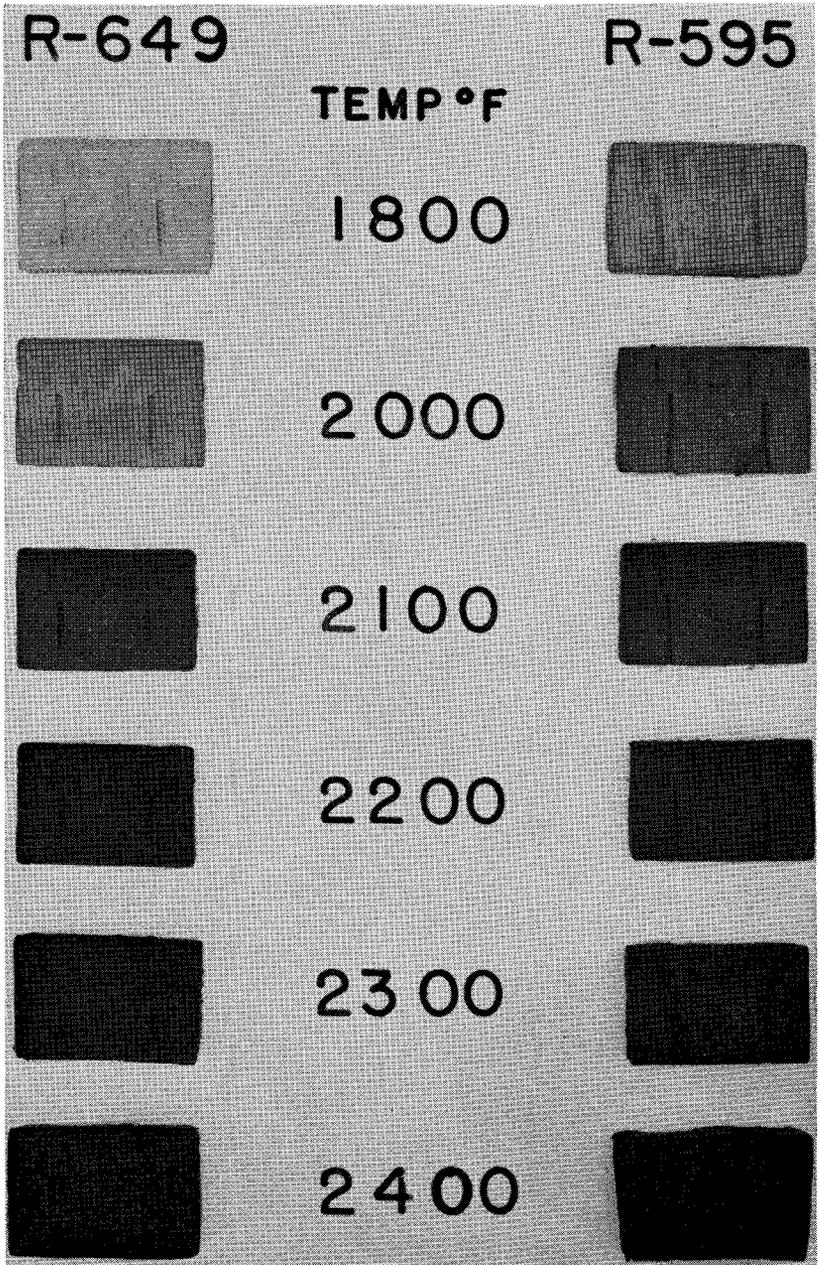
*Fired Properties:*

<u>Temp.</u> <u>°F.</u>	<u>Color</u>	<u>Hardness</u>	<u>% Shk.</u>	<u>% Abs.</u>	<u>Approx.</u> <u>Sp. Gr.</u>
1800	Buff	Soft crumbly	5.5	19.1	2.64
2000	Orange buff	Fairly hard	9.5	11.5	2.59
2100	Dk. red	Very hard	14.0	4.1	2.50
2200	Dk. red brown	Steel hard	14.5	0.1	2.38
2300	Dk. brown	.....	Expanded	4.4	2.20
2400	Dk. brown	.....	Expanded	4.4	1.90

*Bloating Test:* Negative

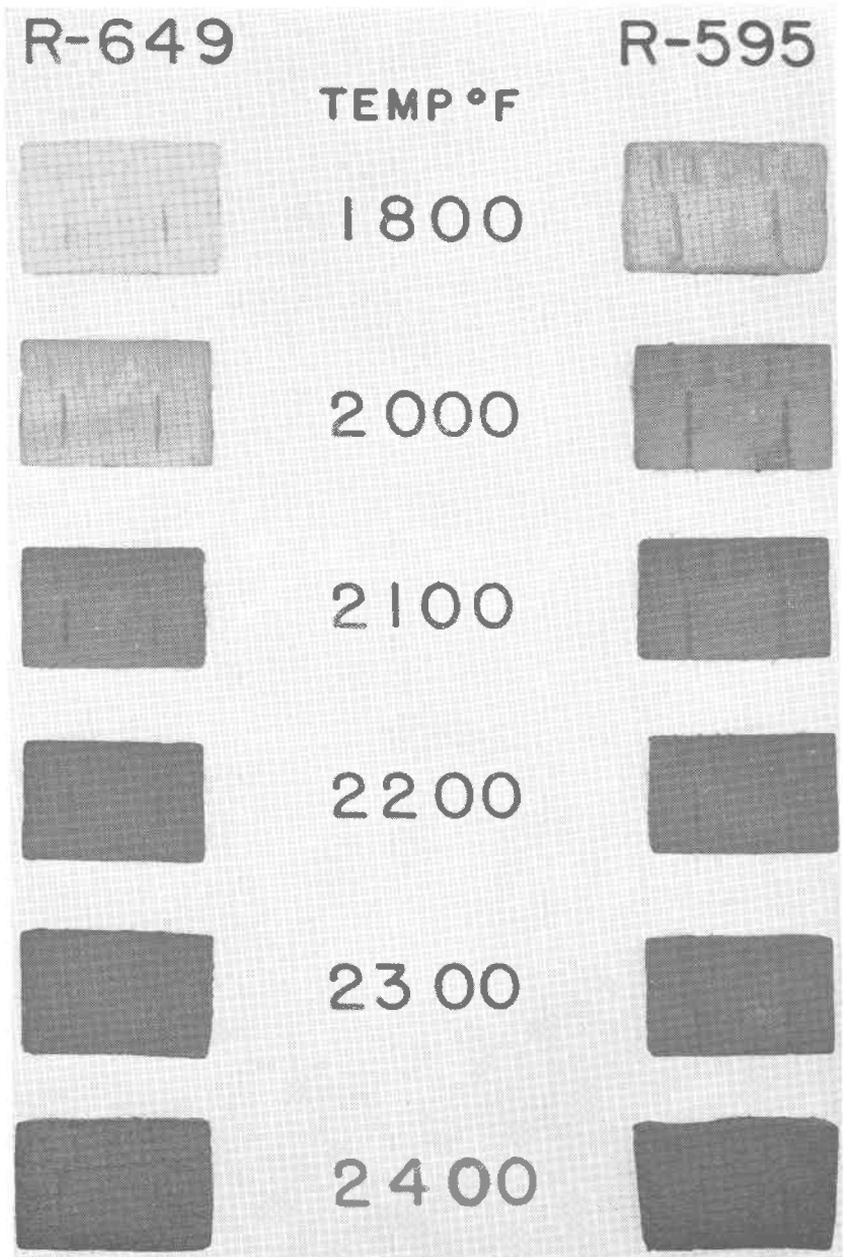
*Potential Use:* Common brick and tile. (Plate 9)

Plate 9



Test briquettes from Martinsburg shale of Ordovician age (Sample R-649) and from Triassic shale (Sample R-595).

Plate 9



Test briquettes from Martinsburg shale of Ordovician age (Sample R-649) and from Triassic shale (Sample R-595).

SAMPLE: R-666

County: Warren

*Locality:* Outcrop on the north side of State Road 613 about a quarter of a mile northwest of Bentonville.

*Description:* The outcrop consists of approximately 165 feet of weathered dark yellowish-orange and grayish-orange shale and interbedded layers of olive-green sandstone. The rocks generally strike N. 45° E. and dip 75° SE., and are overlain by one foot of soil.

*Formation or age:* Martinsburg shale

*Sampled interval:* Composite sample across 160 feet of shale.

*Type:* Shale

*Unfired strength:* Low

*pH:* 5.65

*Raw Properties:* Fair plasticity, short and gritty working, requires 22 percent water for plasticity, no drying defects, 1.0 percent drying shrinkage.

*Fired Properties:*

Temp. °F.	Color	Hardness	% Shk.	% Abs.	Approx. Sp. Gr.
1800	Dk. buff	Soft crumbly	2.0	21.5	2.58
2000	Med. red brown	Very hard	7.5	6.6	2.53
2100	Dk. red brown	Very hard	9.5	5.7	2.46
2200	Med. brown	Steel hard	9.5	2.8	2.35
2300	Med. brown	Steel hard	7.5	2.3	2.31
2400	Dk. brown	.....	Expanded	6.7	2.10

*Potential Use:* Common brick

*Bloating Test:*

Temp. °F.	Bulk Dens.	Lb/ft <sup>3</sup>	% Abs.	Remarks
2000	2.00	124.6	12.5	No bloating
2100	1.97	122.7	3.0	No bloating
2200	1.88	117.1	3.3	No bloating
2300	1.33	82.9	5.6	No bloating

## REFERENCES

- American Society for Testing Materials, Standards, 1958. Designations: C 4-55, C 13-57T, C 24-56, C 27-58, C 29-55T, C 34-57, C 43-55, C 55-55, C 56-57, C 57-57, C 71-55, C 90-52, C 112-52, C 126-57, C 127-42, C 129-52, C 140-56, C 145-52, C 212-54, C 242-56, C 242-58T, C 330-53T, C 331-53T, and C 332-56T.
- Klinefelter, T. A. and Hamlin, H. P., 1957, Syllabus of clay testing: U. S. Bur. Mines, Bull. 565, 67 p.
- Wilson, Hewitt, 1928, Ceramics, clay technology: McGraw-Hill Book Co., Inc., New York, N. Y., p. 3-4.

## GLOSSARY

ASTM—American Society for Testing Materials.

Absorption—the relationship of the weight of the water absorbed to the weight of the dry specimen, expressed in a percent.

Ball clay—a secondary clay, commonly characterized by the presence of organic matter, high plasticity, high dry strength, long vitrification range, and a light color when fired.

Bloating—swelling of a clay material when in the thermoplastic state.

Bloating range—temperature range in which a clay material will bloat.

Casting—forming ceramic ware by introducing a body slip into a porous mold which absorbs sufficient water from the slip to produce a semirigid article.

Die—a mold used for shaping brick, or a form for shaping an extruded column.

Dry-pressed brick—brick formed from moistened ground material under high pressure in a mechanical or hydraulic press.

Drying—removal of uncombined water or other volatile substance from a ceramic raw material or product, usually expedited by low-temperature heating.

Extrusion—the forcing of clay material through an opening or die of suitable shape and size to form a continuous ribbon.

Firing—the controlled heat treatment of ceramic ware in a kiln or furnace, during the process of manufacture, to develop the desired properties.

Firing range—the range of firing temperature within which a ceramic composition develops properties which render it commercially useful.

Flux—a substance that promotes fusion in a given ceramic mixture.

Fusion—the process of melting, usually the result of interaction of two or more materials.

Glaze—a ceramic coating matured to the glassy state on a formed ceramic article, or the material or mixture from which the coating is made.

**Green strength (dry)**—the strength of dry ceramic material before it is fired.

**Green strength (wet)**—the strength of moistened ceramic material before it is fired.

**Grog**—ground up pieces of burned brick or clay, added to the raw clay mixture for the purpose of decreasing the shrinkage and density of the burned ware.

**Jiggering**—forming ceramic ware from a plastic body by differential rotation of a profile tool and mold, the mold having the contour of one surface of the ware and the profile tool that of the other surface.

**Kiln**—a furnace for firing ceramic products such as brick or porcelain.

**Maturing range**—the time-temperature range within which a ceramic body, glaze, or other composition may be fired to yield specified properties.

**pH values**—measure of relative alkalinity and acidity.

**Plasticity**—the property of a moistened material to be deformed under pressure, with the deformed shape being retained when the deforming pressure is removed.

**psi**—pounds per square inch.

**Pyrometric cone equivalent**—the number of that standard pyrometric cone whose tip would touch the supporting plaque simultaneously with a cone of material being investigated when tested in accordance with the method of test for pyrometric cone equivalent of ceramic materials.

**Pyrometric cone**—a small, slender, three-sided pyramid made of ceramic or refractory material for use in determining the time—temperature effect of heating and in obtaining the pyrometric cone equivalent (P. C. E.) of ceramic materials.

**Refractories**—materials, usually non-metallic, used to withstand high temperature.

**Rotary kiln**—an inclined tubular furnace which revolves on its axis.

**Scumming**—the formation of an undesirable residue on the surface of a ceramic product.

- Shrinkage**—the reduction in dimensions of a ceramic material from loss of water or through coalescence upon heat treatment.
- Sinter**—a ceramic material or mixture fired to less than complete fusion, resulting in a coherent mass, or the process involved.
- Slip**—a suspension of ceramic material in a liquid.
- Soft mud process**—the formation of ceramic products by throwing or forcing a mixture of soft consistency into a mold.
- Soluble salts**—compounds formed by the combining of acids and bases. Common water soluble salts found in clay materials include chloride, sulfates, and carbonates of alkalis, alkaline, earths, aluminum, and iron.
- Specific gravity**—the weight of a definite volume of a substance compared with the weight of the same volume of water.
- Stiff mud process**—process by which clay paste is forced through a die as a ribbon which can be cut transversely into brick sizes, usually by a wire.
- Water of plasticity**—percent of water required to plasticize a clay material.
- Workability**—the consistency and moldability of plastic ceramic materials.