

STATE OF DELAWARE
DELAWARE GEOLOGICAL SURVEY
REPORT OF INVESTIGATIONS NO. 14

DELAWARE CLAY RESOURCES

By

Thomas E. Pickett

Newark, Delaware

June, 1970

DELAWARE CLAY RESOURCES

By

**Thomas E. Pickett
Geologist, Delaware Geological Survey**

**In cooperation with the United States Bureau of Mines
Curtis Edgerton, Geologist, Pittsburgh Office**

June, 1970

CONTENTS

	Page
ABSTRACT	1
INTRODUCTION	2
Purpose and Scope	2
Acknowledgments	2
Clay Industry in Delaware	2
GEOLOGY OF DELAWARE	4
SAMPLING AND ANALYSIS	6
CLAY DATA SHEETS	7-65
SUMMARY OF DATA	66
LIGHTWEIGHT AGGREGATE	69
REFERENCES	70

ILLUSTRATIONS

Figure 1.	Sample Locations	3
2.	General Geology of Delaware	5

TABLES

Table 1.	Summary of Data	67
2.	Glossary of Terms	68

ABSTRACT

Forty-eight samples of Delaware clays were collected and tested jointly by the Delaware Geological Survey and the U. S. Bureau of Mines.

Clays potentially useful for face brick are common. The nonmarine Cretaceous Potomac Formation is a potential economic clay at virtually all locations sampled. Some Miocene and Pleistocene clays are also possibilities for brick clays. Other Potomac clays are potential sources for glazed tile, sewer pipe, refractory brick, and stoneware.

Coastal marsh clays, frequently containing much organic debris, are potential source material for lightweight aggregate used in lightweight, strong concrete products. Lightweight aggregate has the potential for augmenting dwindling reserves of crushed stone and gravel aggregate.

INTRODUCTION

Purpose and Scope

A cooperative investigation of Delaware's clay deposits has yielded detailed information on 48 samples. Samples were taken from virtually all accessible geologic horizons and cover the State geographically as well as stratigraphically (Figure 1). The work was done in cooperation with the United States Bureau of Mines (USBM) under an agreement signed in 1967. This cooperative agreement is a continuing one and eventually will result in additional data. This report presents and evaluates information gathered through 1969. Sample collecting, X-ray diffraction analyses, and size analyses were done by the Delaware Geological Survey. The USBM, and their contractees, did the physical tests on the clays.

Acknowledgments

Curtis Edgerton, of the Pittsburgh office of the USBM, has given his full support to the author in this endeavor and has coordinated the physical tests conducted by the USBM and its contractees. His efforts are gratefully acknowledged. Laboratory work was done by the USBM Metallurgical Research Laboratory at the University of Alabama, Tuscaloosa, under the direction of Miles Tyrrell (Samples 1-35); and by Morse Laboratories (Samples 35-48), Sacramento, California. Three special rotary kiln tests were made by I. I. T. Research Institute, Chicago, Illinois, a private research corporation under contract to USBM.

Robert R. Jordan, Nenad Spoljaric, Kenneth D. Woodruff, John C. Miller, Boris T. Bilas of the Delaware Geological Survey staff aided the project in field work, testing clays and discussions with the author. Allan Schaefer, laboratory assistant, helped in analysis of clays and preparation of maps.

Clay Industry in Delaware

Although at the present time (1970) there is but one active brick plant in Delaware, the historic record shows that numerous brick plants have been located in Delaware since Colonial times. Most of these were located in northern New Castle County and utilized clays from the Potomac Formation.

Fine china was made in the 19th Century from kaolinite deposits formed over weathered pegmatite dikes in northwestern Delaware, in the Hockessin area. Commercial china production has been discontinued for over 50 years.

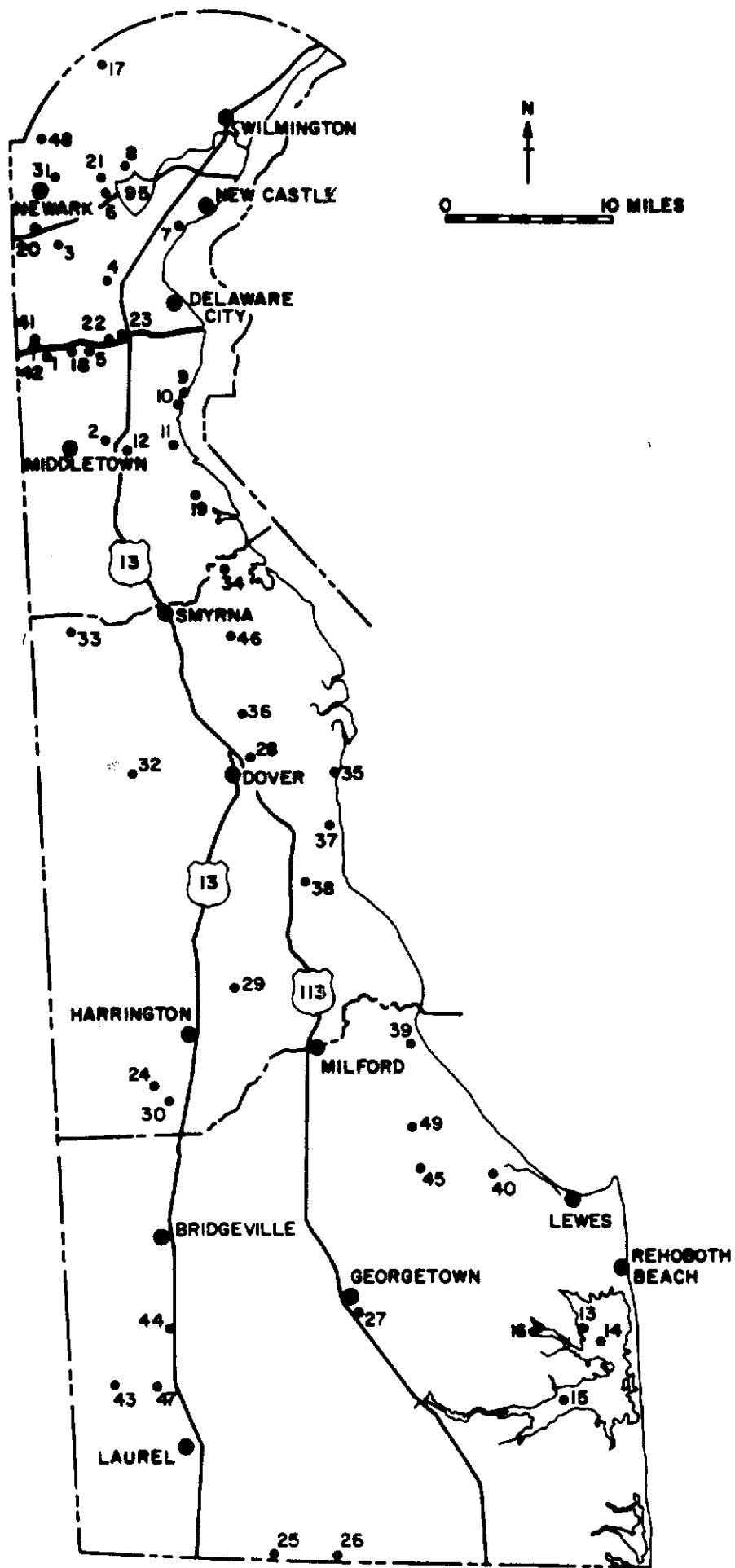


FIGURE 1. SAMPLE LOCATIONS.

No commercial attempts have been made to produce lightweight aggregate in the State, although our tests show that this is a possible new industry for the State. With gravel and crushed rock aggregate approaching high values in Delaware, an opportunity appears to exist for the lightweight aggregate industry.

GEOLOGY OF DELAWARE

Delaware lies in both the Appalachian Piedmont Province and the Atlantic Coastal Plain Province (Figure 2). The Piedmont consists of ancient crystalline rocks, comprising about six percent of the State. The Coastal Plain, the remaining 94 percent, contains unconsolidated sands, clays, and gravels. Clays are found locally in the Piedmont as weathering products of feldspars associated with pegmatite dikes. In the Coastal Plain, most clay deposits are found in the Cretaceous, Miocene and Holocene sediments.

The geologic map (Figure 2) shows the distribution of geologic units sampled.

The Potomac Formation, the oldest unit of the Coastal Plain, consists of clays and sands deposited probably in a delta environment with associated floodplains.

After deposition of this unit, the seas encroached upon the land and the Upper Cretaceous marine deposits were laid down. There is a general alternation of clayey and sandy units as the seas retreated (sandy) and advanced (clayey) over the area that is now Delaware. Glauconite (greensand) is more abundant in the uppermost Cretaceous units than it is in the lower ones. The greensand deposits are composed of sand-sized particles of a clay (glauconite) which is a complex potash and iron-bearing silicate.

There appears to be no break in sedimentation until the end of Eocene time. The seas remained over the area until this time. The greatest concentration of greensand is in Rancocas Formation deposits of Paleocene-Eocene age.

At the end of Eocene time, the seas retreated. No deposits of Oligocene age are found in Delaware.

During the Miocene, seas returned over the State at least as far north as the Townsend area. Blue-gray silts and clays, with associated sand layers, were deposited in the southern three-fourths of the State.

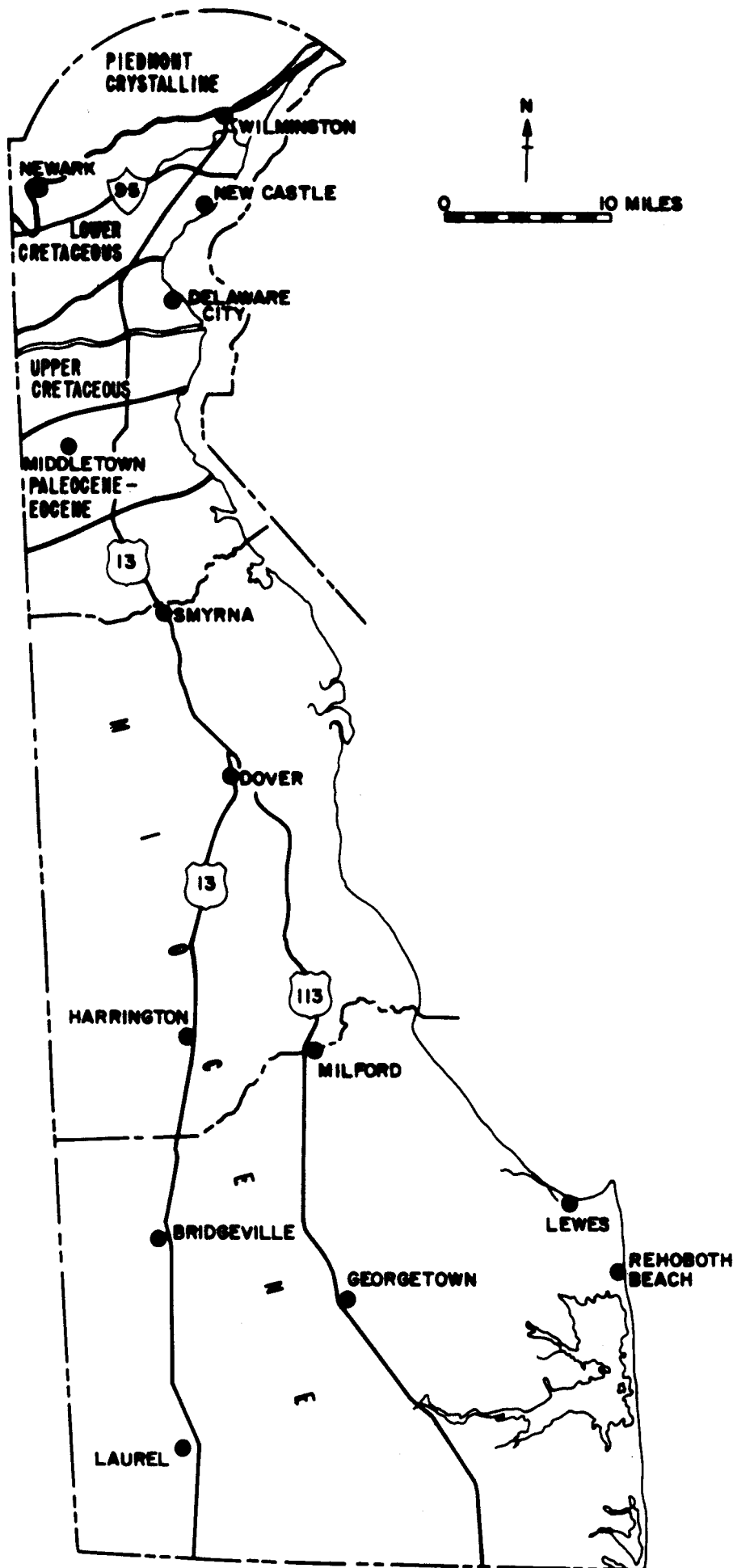


FIGURE 2. GENERAL GEOLOGY OF DELAWARE (PLEISTOCENE REMOVED).

No proven deposits of Pliocene age exist.

The advance and retreat of Pleistocene glaciers changed sea level and caused deposition of a veneer, consisting mostly of sands and gravels. Fine-grained sands and some Pleistocene clays are found in southern Kent County and Sussex County.

Holocene (Recent) deposits of marsh silts and clays in eastern Delaware adjacent to the Delaware River and Bay and its tributaries form the youngest horizon of clay materials tested. These deposits may be 70 feet or more thick where they fill old stream valleys.

SAMPLING AND ANALYSIS

Figure 1 shows the location of sites from which clay samples were taken for the study. Representative samples were collected by digging away the weathered zone and obtaining a ten-pound composite channel sample of the unweathered clay. Field notes were made approximating the dimensions of the clay deposit and the location. Locations on the data sheets are based on Delaware State Highway Department Maintenance map route numbers. Some samples were collected at depth by power auger.

Three samples, weighing approximately 500 pounds each, were collected for testing for lightweight aggregate possibilities by the rotary kiln process.

A split of each sample was retained by the Delaware Geological Survey. This clay was analyzed by X-ray diffraction and wet sieved to obtain the percentage of sand to silt-clay.

The samples sent to the Bureau of Mines were subjected to various tests of their physical properties. The laboratory procedure followed that of Hamlin and Templin (1961). Water of plasticity, slow and quick firing tests were made.

Sample color was described, and the Munsell soil color charts (1954) were used for Samples 35 through 48 (Morse Laboratories). Samples 1-35 were described by USBM who did not use the Munsell system.

Three rotary kiln tests were run to test the bloating characteristics under industrial conditions. The kiln was fired to a temperature shown by quick firing tests to produce a bloated clay weighing between 45 and 60 pounds per cubic foot. This is the preferred density for commercial lightweight aggregate.

CLAY DATA SHEETS

SAMPLE NO.: 1 FORMATION: Potomac COUNTY: New CastleLocation: South end of Summit Bridge, Chesapeake & Delaware Canal.Description: Light gray, very plastic clay.Raw Properties:Water of Plasticity, Percent 19.2 Working Properties Low plasticityDrying Defects None Drying Shrinkage, Percent 2.5 Dry Strength FairSlow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	<u>Cream</u>	<u>2</u>	<u>2.5</u>	<u>15.9</u>	<u>29.4</u>	<u>1.85</u>
1900	<u>Cream</u>	<u>2</u>	<u>2.5</u>	<u>15.2</u>	<u>28.3</u>	<u>1.86</u>
2000	<u>Cream</u>	<u>2</u>	<u>2.5</u>	<u>14.2</u>	<u>27.0</u>	<u>1.90</u>
2100	<u>Ivory</u>	<u>3</u>	<u>5.0</u>	<u>13.6</u>	<u>26.1</u>	<u>1.92</u>
2200	<u>Ivory</u>	<u>4</u>	<u>5.0</u>	<u>12.3</u>	<u>24.0</u>	<u>1.95</u>
2300	<u>Ivory</u>	<u>5</u>	<u>5.0</u>	<u>11.1</u>	<u>21.9</u>	<u>1.97</u>

Bloating Test NegativeOther Tests pH - 4.5. Not effervescent with HCl. Clay minerals: kaolinite.vermiculite. Sand 44%, silt-clay 56%.Potential Use Face brick, glazed structural tile.Remarks: Should fire to "MW" face brick specifications at about 2200°F.Good body color for glazed tile.

SAMPLE NO.: 2 FORMATION: Rancocas COUNTY: New Castle

Location: Road 429 at Drawyer's Creek

Description: Greensand (glaucanite).

Raw Properties:

Water of Plasticity, Percent - Working Properties No plasticity

Drying Defects - Drying Shrinkage, Percent - Dry Strength -

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	No bond	-	-	-	-	-
1900						
2000						
2100						
2200						
2300						

Bloating Test Negative

Other Tests pH - 5.3. Not effervescent with HCl. Clay minerals: illite, mont-
morillonite, glaucanite. Sand 87%, silt-clay 13%.

Potential Use None (ceramics).

Remarks: Green sands have been used for water-softening and as fertilizers.

SAMPLE NO.: 3 FORMATION: Potomac COUNTY: New Castle

Location: Road 356 at Belltown Run.

Description: Mottled red and grayish sandy clay.

Raw Properties:

Water of Plasticity, Percent 18.9 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	2.5	18.2	32.4	1.78
1900	Tan	3	5.0	16.4	29.5	1.80
2000	Tan	4	5.0	15.5	28.4	1.83
2100	Lt. brown	4	5.0	12.8	24.3	1.90
2200	Lt. brown	5	7.5	12.2	23.4	1.92
2300	Gray brown	6	7.5	8.7	17.7	2.03

Bloating Test Negative

Other Tests pH - 5.0. Not effervescent with HCl. Sand 45%, silt-clay 55%.

Clay minerals: kaolinite, illite.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2100°F.

Low dry strength; marginal color.

SAMPLE NO.: 4 FORMATION: Potomac COUNTY: New Castle

Location: Road 71, 1/2 mile south of Red Lion.

Description: Gray and reddish gray clay.

Raw Properties:

Water of Plasticity, Percent 19.4 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	2.5	19.9	34.2	1.72
1900	Tan	2	2.5	18.6	32.4	1.74
2000	Tan	3	2.5	17.8	31.3	1.76
2100	Lt. brown	4	5.0	16.5	29.5	1.79
2200	Lt. brown	5	5.0	15.1	27.6	1.83
2300	Gray brown	6	5.0	11.9	22.8	1.92

Bloating Test Negative

Other Tests pH - 5.1. Not effervescent with HCl. Sand 30%, silt-clay 70%.

Clay minerals: kaolinite, illite.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2300°F.

Low dry strength; marginal color.

SAMPLE NO.: 5 FORMATION: Potomac COUNTY: New Castle

Location: Road 419, Southwest Iron Hill.

Description: Mottled ocher, red, grayish clays.

Raw Properties:

Water of Plasticity, Percent 24.0 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	2.5	25.6	40.5	1.58
1900	Tan	2	2.5	23.7	38.2	1.61
2000	Tan	2	2.5	22.1	36.9	1.67
2100	Lt. brown	3	5.0	18.2	32.2	1.77
2200	Lt. brown	4	7.5	15.8	29.1	1.84
2300	Gray brown	5	7.5	11.4	22.5	1.97

Bloating Test Negative

Other Tests pH - 5.3. Not effervescent with HCl. Sand 39%, silt-clay 61%.

Clay minerals: kaolinite, illite.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2300°F.

Low dry strength.

SAMPLE NO.: 6 FORMATION: Potomac COUNTY: New Castle

Location: Highway 273, 1 mile east of Christiana.

Description: Sandy, mottled red and gray clay.

Raw Properties:

Water of Plasticity, Percent 22.4 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Pink	2	2.5	20.3	35.1	1.73
1900	Pink	2	2.5	19.6	34.1	1.74
2000	Pink	2	5.0	16.5	30.4	1.84
2100	Lt. pink	3	7.5	16.1	29.8	1.85
2200	Lt. pink	4	7.5	14.5	27.6	1.90
2300	Gray	5	7.5	12.9	25.0	1.94

Bloating Test Negative

Other Tests pH - 5.3. Not effervescent with HCl. Sand 29%, silt-clay 71%.

Clay minerals: kaolinite, illite.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2300°F.

SAMPLE NO.: 7 FORMATION: Potomac COUNTY: New Castle

Location: Highway 9, 2 miles south of New Castle.

Description: Mottled red and gray, little ocher, not very plastic clay.

Raw Properties:

Water of Plasticity, Percent 22.2 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Pink	3	2.5	16.2	28.7	1.77
1900	Pink	4	2.5	15.9	28.4	1.79
2000	Lt. pink	4	2.5	15.8	28.3	1.79
2100	Tan	4	5.0	15.6	27.9	1.79
2200	Tan	5	5.0	15.5	28.1	1.81
2300	Gray	6	5.0	13.5	25.1	1.86

Bloating Test Negative

Other Tests pH - 5.7. Not effervescent with HCl. Clay minerals: kaolinite,
illite, montmorillonite. Sand 27%, silt-clay 73%.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2200°F.

Low dry strength.

SAMPLE NO.: 8 FORMATION: Potomac COUNTY: New Castle

Location: I-95, Basin Road.

Description: Very tough mottled red and white clay.

Raw Properties:

Water of Plasticity, Percent 21.9 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Pink	2	5.0	19.8	35.2	1.78
1900	Pink	2	5.0	18.7	33.5	1.79
2000	Pink	3	5.0	16.3	30.5	1.87
2100	Lt. brown	4	7.5	10.8	22.2	2.06
2200	Lt. brown	5	10.0	5.0	11.4	2.27
2300	Gray brown	5	10.0	0.7	1.6	2.35

Bloating Test Negative

Other Tests pH - 4.6. Not effervescent with HCl. Sand 57%, silt-clay 43%.

Clay minerals: kaolinite, illite.

Potential Use Face brick.

Remarks: Should fire to "SW" face brick specifications at about 2150°F.

SAMPLE NO.: 9 FORMATION: Marsh COUNTY: New Castle

Location: Highway 9, 1 mile south of Port Penn.

Description: Grayish "strawy" unctuous clay.

Raw Properties:

Water of Plasticity, Percent 39.9 Working Properties High plasticity

Drying Defects None Drying Shrinkage, Percent 5.0 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Lt. brown	3	5.0	40.4	52.1	1.29
1900	Lt. brown	3	5.0	38.3	50.6	1.32
2000	Lt. brown	4	10.0	29.2	43.2	1.48
2100	Brown	5	17.5	14.1	26.8	1.90
2200	Dk. brown	5	20.0	4.3	8.8	2.04
2300	-	-	Melted	-	-	-

Bloating Test Positive

Other Tests pH - 5.3. Not effervescent with HCl. Sand 59%, silt-clay 41%.

Clay minerals: kaolinite, illite, chlorite.

Potential Use Lightweight aggregate (marginal).

Remarks: Not suitable for use as the principal component in vitreous clay
products. Abrupt vitrification.

PRELIMINARY BLOATING TEST

SAMPLE NO.: 9

Crushing characteristics Angular

Particle size 3/4" lumps Retention time 15 minutes

Temp. °F	Percent absorption	Bulk density ₃		Remarks
		gm/cc	Lb/ft ³	
1800	-	-	-	-
1900	23.9	1.24	77.4	Slight expansion
2000	15.7	1.07	66.8	Fair pore structure
2100	16.8	1.02	63.6	Some large pores
2200	-	-	-	-
2300	-	-	-	-

Comments Marginal for lightweight aggregate. (Heavy; short range).

SAMPLE NO.: 10 FORMATION: Marsh COUNTY: New Castle

Location: Highway 9 at Augustine River

Description: Brownish gray, unctuous clay

Raw Properties:

Water of Plasticity, Percent 34.0 Working Properties High plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	5.0	34.4	47.8	1.39
1900	Tan	2	5.0	33.5	46.6	1.39
2000	Lt. brown	2	7.5	29.9	43.9	1.47
2100	Brown	3	10.0	19.6	32.9	1.68
2200	Dk. brown	4	12.5	7.3	13.7	1.88
2300	-	-	Melted	-	-	-

Bloating Test Positive

Other Tests pH - 5.6. Not effervescent with HCl. Sand 65%, silt-clay 35%,
kaolinite, illite, montmorillonite.

Potential Use Lightweight aggregate (marginal).

Remarks: Not suitable for use as the principal component in vitreous clay
products. Abrupt vitrification.

PRELIMINARY BLOATING TEST

SAMPLE NO.: 10

Crushing characteristics Angular

Particle size 3/4 lumps Retention time 15 minutes

Temp. °F	Percent absorption	Bulk density gm/cc Lb/ft ³		Remarks
1800	-	-	-	-
1900	22.3	1.37	85.5	No expansion
2000	15.8	1.19	74.3	Slight expansion
2100	17.6	1.04	64.9	Good pore structure
2200	-	-	-	-
2300	-	-	-	-

Comments Marginal for lightweight aggregate (heavy).

SAMPLE NO.: 11 FORMATION: Marsh COUNTY: New Castle

Location: Highway 9 at Appoquinimink River.

Description: Grayish clay with some brown areas and straw.

Raw Properties:

Water of Plasticity, Percent 39.2 Working Properties High plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	5.0	41.6	5.28	1.27
1900	Tan	2	5.0	39.6	51.1	1.29
2000	Lt. brown	2	7.5	33.5	46.6	1.39
2100	Brown	3	12.5	18.7	32.4	1.73
2200	-	-	Expanded	-	-	-
2300	-	-	-	-	-	-

Bloating Test Positive

Other Tests pH - 5.8. Not effervescent with HCl. Sand 58%, silt-clay 42%.

Clay minerals: kaolinite, illite, montmorillonite.

Potential Use Lightweight aggregate.

Remarks: Not suitable for use as the principal component in vitreous clay
products. Abrupt vitrification.

PRELIMINARY BLOATING TEST

SAMPLE NO. : 11

Crushing characteristics Angular

Particle size 3/4" lumps Retention time 15 minutes

Temp. °F	Percent absorption	Bulk Density		Remarks
		gm/cc	Lb/ft ³	
1800	-	-	-	-
1900	11.1	1.41	88.0	No expansion
2000	26.0	1.28	79.9	Slight expansion
2100	40.0	0.92	57.4	Good pore structure
2200	-	-	-	-
2300	-	-	-	-

Comment Promising for lightweight aggregate.

CLAY EVALUATION: ROTARY KILN TEST

SAMPLE NO.: 11

RAW MATERIAL

Screen Analysis: (Crushed through 1" jaws and 3/4" rollers)

<u>Through</u>	<u>Retained on</u>	<u>Weight, percent</u>	<u>Cumulative, percent</u>
3/4"	1/2"	29.05	29.05
1/2"	4-mesh	29.30	58.35
4-mesh	8-mesh	17.60	75.95
8-mesh		24.05	100.00

Comments: +3/4" 13.06% of total crushed material. Blocky fragments.

Total weight dry material 232 lb. Very wet, dried in oven.

Firing Data:

Size range of feed -3/4+8 mesh Pour weight of feed 44.24 pcf

Bloating temperature 2150°F Logging temperature * 2200°F
 *Nodules sticking together)

FIRED MATERIAL

(All fired material crushed through roll crusher)

Screen Analysis: * Percentages by weight passing sieves

Size designation:	<u>3/4"</u>	<u>1/2"</u>	<u>No. 4</u>	<u>No. 8</u>	<u>No. 16</u>	<u>No. 50</u>	<u>No. 100</u>
Fine aggregate:	-	100	5.76	1.25	0.75	<0.50	<0.50
Coarse aggregate:	100	63.26	3.10	0.32	-	-	-

Loose Pour Weights:*

Fine aggregate: 37.84 pcf

Coarse aggregate: 34.70 pcf

*ASTM Designation C 331-59T

Comments: Aggregate partially logged. Fair pore structure. Good crush strength and quench resistance. Color dark brown. Clay indurated at 2100°F may also be a good aggregate 45pcf.

SAMPLE NO.: 12 FORMATION: Marsh COUNTY: New Castle

Location: Highway 299 at Appoquinimink River.

Description: Brownish gray, strawy clay.

Raw Properties:

Water of Plasticity, Percent 42.1 Working Properties High plasticity

Drying Defects None Drying Shrinkage, Percent 7.5 Dry Strength High

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	10.0	44.6	54.4	1.22
1900	Tan	2	12.5	40.0	51.6	1.29
2000	Lt. brown	3	20.0	28.7	43.1	1.50
2100	Brown	4	27.5	8.5	17.7	2.09
2200	-	-	Expanded	-	-	-
2300	-	-	-	-	-	-

Bloating Test Negative

Other Tests pH - 5.4. Not effervescent with HCl. Sand 71%, silt-clay 29%.

Clay minerals: kaolinite, illite, vermiculite.

Potential Use Not suitable for use as the principal component in vitreous

clay products. Abrupt vitrification.

Remarks: _____

SAMPLE NO.: 13 FORMATION: Bay COUNTY: Sussex
(JCK 231)

Location: West Rehoboth Bay.

Description: Gray clay.

Raw Properties:

Water of Plasticity, Percent 42.8 Working Properties High plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Lt. purple	Poor bond	2.5	-	-	-
1900	Lt. purple	Poor bond	2.5	-	-	-
2000	Purple	3	15.0	22.6	38.9	1.72
2100	-	-	Melted	-	-	-
2200	-	-	-	-	-	-
2300	-	-	-	-	-	-

Bloating Test Negative

Other Tests pH - 5.7. Not effervescent with HCl. Sand 45%, silt-clay 55%.

Clay minerals: kaolinite, illite.

Potential Use Not suitable for use as the principal component in vitreous
clay products.

Remarks: Poor bond; abrupt vitrification.

SAMPLE NO.: 14 FORMATION: Bay COUNTY: Sussex
(JCK 230)

Location: Mid Rehoboth Bay

Description: Gray clay.

Raw Properties:

Water of Plasticity, Percent 22.0 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	2.5	34.2	46.9	1.37
1900	Tan	3	2.5	28.4	41.7	1.47
2000	Tan	3	2.5	27.2	40.8	1.50
2100	Brown	4	5.0	20.8	34.1	1.64
2200	-	-	Expanded	-	-	-
2300	-	-	-	-	-	-

Bloating Test Negative

Other Tests pH - 6.3. Not effervescent with HCl. Sand 53%, silt-clay 47%,
kaolinite, illite.

Potential Use Not suitable for use as the principal component in vitreous
clay products.

Remarks: Abrupt vitrification.

SAMPLE NO.: 15 FORMATION: Bay COUNTY: Sussex

(JCK 232)

Location: West Indian River Bay

Description: Gray clay

Raw Properties:

Water of Plasticity, Percent 25.7 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	5.0	30.2	46.5	1.54
1900	Tan	3	5.0	30.1	58.4	1.94
2000	Brown	4	7.5	26.0	54.0	2.08
2100	Dk. brown	5	15.0	5.8	12.4	2.15
2200	-	-	Expanded	-	-	-
2300	-	-	-	-	-	-

Bloating Test Positive

Other Tests pH - 7.3. Not effervescent with HCl. Sand 45%, silt-clay 55%,
kaolinite, illite.

Potential Use Not suitable for use as the principal component in vitreous
clay products.

Remarks: Abrupt vitrification.

PRELIMINARY BLOATING TEST

SAMPLE NO.: 15 (JCK 232)

Crushing characteristics Angular

Particle size 3/4" lumps Retention time 15 minutes

Temp. °F	Percent absorption	Bulk density		Remarks
		gm/cc	Lb/ft ³	
1800	-	-	-	-
1900	24.9	1.51	94.2	No expansion
2000	14.8	1.53	95.5	No expansion
2100	12.3	0.95	59.3	Overfired; vitreous
2200	-	-	-	-
2300	-	-	-	-

Comments Not suitable for lightweight aggregate (short range).

SAMPLE NO.: 16 FORMATION: Estuary COUNTY: Sussex
(JCK 236)

Location: Herring Creek, near Angola.

Description: Gray clay.

Raw Properties:

Water of Plasticity, Percent 60.8 Working Properties High plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Pink	2	10.0	81.6	64.5	0.79
1900	Pink	2	12.5	72.0	61.2	0.85
2000	Lt. brown	3	25.0	31.3	39.7	1.27
2100	Brown	4	32.5	5.1	9.2	1.80
2200	-	-	Melted	-	-	-
2300	-	-	-	-	-	-

Bloating Test Positive

Other Tests pH - 6.6. Not effervescent with HCl. Sand 72%, silt-clay 28%.

Clay minerals: kaolinite, illite, montmorillonite(?).

Potential Use Lightweight aggregate (marginal).

Remarks: Not suitable for use as the principal component in vitreous clay
products. Abrupt vitrification.

PRELIMINARY BLOATING TEST

SAMPLE NO.: 16 (JCK 236)

Crushing characteristics Angular

Particle size 3/4" lumps Retention time 15 minutes

Temp. °F	Percent absorption	Bulk density		Remarks
		gm/cc	Lb/ft ³	
1800	-	-	-	-
1900	42.8	1.25	78.0	No expansion
2000	19.5	1.07	66.8	Slight expansion
2100	19.7	1.04	64.9	Good pore structure
2200	-	-	-	-
2300	-	-	-	-

Comments Marginal for lightweight aggregate (heavy).

SAMPLE NO.: 17 FORMATION: Weathered Pegmatite COUNTY: New Castle

Location: One mile northeast of Hockessin on Yorklyn Road.

Description: Weathered brownish pegmatite clay.

Raw Properties:

Water of Plasticity, Percent 22.4 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	2.5	19.9	33.0	1.66
1900	Tan	2	2.5	19.5	32.4	1.66
2000	Tan	2	2.5	18.3	31.3	1.71
2100	Lt. brown	3	2.5	17.2	29.6	1.72
2200	Brown	4	5.0	15.5	27.0	1.74
2300	Gray brown	5	5.0	11.2	20.4	1.82

Bloating Test Negative

Other Tests pH - 5.9. Not effervescent with HCl. Sand 56%, silt-clay 44%.

Clay minerals: kaolinite, illite, chlorite and vermiculite.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2300°F.

Low dry strength.

SAMPLE NO.: 18 FORMATION: Merchantville COUNTY: New Castle

Location: Chesapeake & Delaware Canal, 1/2 mile east of Highway 896.

Description: Dark gray clayey fine sand.

Raw Properties:

Water of Plasticity, Percent 18.7 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	2.5	18.9	31.4	1.66
1900	Tan	2	2.5	19.5	32.0	1.64
2000	Brown	2	2.5	18.4	30.5	1.66
2100	Brown	2	2.5	17.7	29.6	1.67
2200	Dk. brown	3	2.5	13.3	22.7	1.71
2300	Red brown	4	2.5	7.6	13.1	1.72

Bloating Test Negative

Other Tests pH - 4.9. Not effervescent with HCl. Sand 66%, silt-clay 34%.

Clay minerals: kaolinite, illite, vermiculite.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2250°F.

Low dry strength; poor ceramic bond.

SAMPLE NO.: 19 FORMATION: Miocene COUNTY: New Castle

Location: Intersection, Highway 9 - Road 454.

Description: Gray, rust-mottled sandy clay.

Raw Properties:

Water of Plasticity, Percent 18.9 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	2.5	19.5	33.0	1.69
1900	Tan	2	2.5	17.7	30.3	1.71
2000	Tan	3	5.0	15.0	26.6	1.77
2100	Lt. brown	4	5.0	11.2	20.9	1.87
2200	Brown	5	10.0	6.9	13.8	2.00
2300	Gray	6	10.0	3.3	6.8	2.05

Bloating Test Negative

Other Tests pH - 5.2. Not effervescent with HCl. Sand 30%, silt-clay 70%.

Clay minerals: kaolinite, illite, chlorite.

Potential Use Face brick.

Remarks: Should fire to "SW" face brick specifications at about 2150°F.

SAMPLE NO.: 20 FORMATION: Potomac COUNTY: New Castle

Location: Highway 896, 1/2 mile north of Highway 40.

Description: Gray to buff, mottled sandy clay; sandy mottles.

Raw Properties:

Water of Plasticity, Percent 17.7 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	Poor bond	0.0	19.2	32.8	1.71
1900	Tan	2	0.0	18.3	31.8	1.74
2000	Lt. brown	3	0.0	13.7	25.5	1.86
2100	Lt. brown	4	0.0	12.5	23.7	1.90
2200	Dk. brown	5	2.5	6.9	14.4	2.09
2300	Dk. gray	6	5.0	3.0	6.3	2.11

Bloating Test Negative

Other Tests pH - 5.8. Not effervescent with HCl. Sand 38%, silt-clay 62%.

Clay minerals: kaolinite, illite, vermiculite.

Potential Use Low shrinkage component in face brick mixtures.

Remarks: Low green strength. Poor color.

SAMPLE NO.: 21 FORMATION: Potomac COUNTY: New Castle

Location: I-95, one mile east of Highway 273.

Description: Mottled tan and red clay.

Raw Properties:

Water of Plasticity, Percent 22.8 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Lt. red	2	0.0	21.2	36.3	1.71
1900	Lt. red	2	0.0	19.9	34.4	1.73
2000	Lt. brown	3	2.5	13.4	25.9	1.93
2100	Lt. brown	4	2.5	12.1	23.8	1.97
2200	Dk. brown	5	5.0	7.7	16.3	2.12
2300	Dk. brown	6	7.5	4.7	10.5	2.24

Bloating Test Negative

Other Tests pH - 5.5. Not effervescent with HCl. Sand 15%, silt-clay 85%.

Clay minerals: kaolinite, illite, vermiculite.

Potential Use Face brick; sewer pipe.

Remarks: Should fire to "SW" face brick specifications at about 2150°F.

SAMPLE NO.: 22 FORMATION: Marshalltown COUNTY: New Castle

Location: Chesapeake & Delaware Canal, 1/3 mile west of Highway 13.

Description: Tan and gray clayey silt.

Raw Properties:

Water of Plasticity, Percent 19.0 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	0.0	13.8	25.4	1.84
1900	Tan	3	2.5	12.5	23.9	1.91
2000	Lt. brown	4	5.0	9.0	17.9	1.99
2100	Lt. brown	5	5.0	8.5	17.0	2.01
2200	Red-brown	6	7.5	6.4	13.1	2.05
2300	-	-	Expanded	-	-	-

Bloating Test Negative

Other Tests pH - 6.3. Not effervescent with HCl. Sand 44%, silt-clay 56%,
kaolinite, illite.

Potential Use Low shrinkage component in face brick structure.

Remarks: Low green strength. Poor color.

SAMPLE NO.: 23 FORMATION: Englishtown COUNTY: New Castle

Location: Chesapeake & Delaware Canal, 1/4 mile west of Highway 13.

Description: Dark gray, micaceous clayey silt.

Raw Properties:

Water of Plasticity, Percent 20.8 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	0.0	19.0	32.1	1.69
1900	Tan	3	2.5	17.5	30.5	1.74
2000	Lt. brown	4	5.0	9.7	18.7	1.93
2100	Lt. brown	4	7.5	9.1	17.6	1.93
2200	-	-	Expanded	-	-	-
2300	-	-	-	-	-	-

Bloating Test Positive

Other Tests pH - 3.0. Not effervescent with HCl. Sand 50%, silt-clay 50%.

Clay minerals: kaolinite, illite.

Potential Use Lightweight aggregate.

Remarks: Low green strength. Abrupt vitrification.

PRELIMINARY BLOATING TEST

SAMPLE NO.: 23

Crushing characteristics _____

Particle size 3/4" lumps Retention time 15 minutes

Temp. °F	Percent absorption	<u>Bulk density</u>		Remarks
		gm/cc	Lb ft ³	
1800				
1900				
2000				
2100	13.8	1.58	98	No expansion
2200	13.5	1.32	82	Slight expansion
2300	18.3	0.90	56	Good pore structure

Comments Marginal raw material for lightweight aggregate (refractory).

SAMPLE NO.: 24 FORMATION: Pleistocene COUNTY: Kent

Location: Road 311, 1 mile west of Highway 13

Description: Gray sandy mud.

Raw Properties:

Water of Plasticity, Percent 18.5 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Cream	Poor bond	0.0	19.6	32.7	1.67
1900	Cream	Poor bond	0.0	19.2	32.6	1.70
2000	Tan	2	0.0	17.8	30.4	1.71
2100	Tan	3	0.0	17.1	29.4	1.72
2200	Buff	4	0.0	15.0	26.9	1.79
2300	Buff	5	2.5	11.8	22.1	1.87

Bloating Test Negative

Other Tests pH - 5.1. Not effervescent with HCl. Sand 45%, silt-clay 55%,
kaolinite, illite, vermiculite.

Potential Use Low shrinkage component in face brick mixtures.

Remarks: Low green strength. High absorption at all firing temperatures.

SAMPLE NO.: 25 FORMATION: Pleistocene COUNTY: Sussex

Location: Road 419, 1/3 mile east of Road 455.

Description: Sandy gray and tan mud.

Raw Properties:

Water of Plasticity, Percent 13.0 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	3	0.0	15.5	28.7	1.85
1900	Tan	4	0.0	14.0	26.9	1.92
2000	Tan	4	0.0	13.4	25.9	1.93
2100	Tan	4	0.0	13.2	25.6	1.93
2200	Tan	4	0.0	12.4	23.9	1.93
2300	Buff	4	0.0	11.8	22.8	1.93

Bloating Test Negative

Other Tests pH - 5.1. Not effervescent with HCl. Sand 57%, silt-clay 43%.

Clay minerals: kaolinite (?), vermiculite (?).

Potential Use Low shrinkage component in face brick mixtures.

Remarks: Low green strength. High absorption at all firing temperatures.

SAMPLE NO.: 26 FORMATION: Pleistocene COUNTY: Sussex

Location: Intersection, Roads 419 and 26.

Description: Slightly sandy gray clay overlies ocher finer clay.

Raw Properties:

Water of Plasticity, Percent 21.5 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Orange	2	0.0	19.7	34.7	1.76
1900	Orange	3	2.5	18.1	32.6	1.80
2000	Orange	4	5.0	16.1	29.8	1.85
2100	Lt. brown	4	5.0	14.4	27.2	1.89
2200	Dk. brown	4	5.0	12.6	24.3	1.93
2300	Dk. brown	5	5.0	11.4	22.2	1.95

Bloating Test Negative

Other Tests pH - 5.1. Not effervescent with HCl. Sand 43%, silt-clay 57%.

Clay minerals: illite, montmorillonite.

Potential Use Low shrinkage component in face brick mixtures.

Remarks: Low green strength. High absorption of all firing temperatures.

SAMPLE NO.: 27 FORMATION: Pleistocene COUNTY: Sussex

Location: Intersection Highway 113 and Road 431.

Description: Tan and gray sandy clay.

Raw Properties:

Water of Plasticity, Percent 15.3 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	3	0.0	16.3	29.2	1.79
1900	Tan	4	0.0	15.4	28.5	1.85
2000	Tan	4	0.0	13.3	25.3	1.90
2100	Lt. brown	4	0.0	11.4	22.1	1.94
2200	Lt. brown	5	0.0	11.0	21.9	1.99
2300	Gray	6	2.5	9.2	18.4	2.00

Bloating Test Negative

Other Tests pH - 5.7. Not effervescent with HCl. Sand 49%, silt-clay 51%.

Clay minerals: kaolinite, illite.

Potential Use Low shrinkage component in face brick mixtures.

Remarks: Low green strength. High absorption at all firing temperatures.

SAMPLE NO.: 28 FORMATION: Miocene (?) COUNTY: Kent

Location: Road 66, 1 1/2 miles east of Highway 13.

Description: Gray and tan sandy clay.

Raw Properties:

Water of Plasticity, Percent 22.3 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 0.0 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	0.0	21.6	35.8	1.66
1900	Tan	2	0.0	19.7	33.1	1.68
2000	Lt. brown	2	0.0	17.2	30.1	1.75
2100	Brown	3	0.0	13.7	25.2	1.84
2200	Dk. brown	4	5.0	8.0	16.2	2.02
2300	-	Expanded	-	-	-	-

Bloating Test Negative

Other Tests pH - 5.1. Not effervescent with HCl. Sand 18%, silt-clay 82%.

Clay minerals: kaolinite, illite, vermiculite.

Potential Use Low shrinkage component in face brick mixtures.

Remarks: Low green strength. Abrupt vitrification.

SAMPLE NO.: 29 FORMATION: Miocene COUNTY: Kent

Location: Killen Pond State Highway gravel pit.

Description: Tan and gray silt-clay.

Raw Properties:

Water of Plasticity, Percent 16.4 Working Properties Low plasticity

Drying Defects None Drying Shrinkage, Percent 2.5 Dry Strength Low

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Pink	2	2.5	21.3	35.7	1.68
1900	Pink	2	2.5	21.1	35.7	1.69
2000	Lt. Brown	2	5.0	20.8	35.4	1.70
2100	Lt. Brown	3	5.0	20.0	34.6	1.73
2200	Red-Brown	4	5.0	18.8	32.1	1.71
2300	Gray Brown	4	5.0	17.6	31.3	1.78

Bloating Test Negative

Other Tests pH - 6.0. Not effervescent with HCl. Sand 64%, silt-clay 36%.

Clay minerals: kaolinite, illite, montmorillonite.

Potential Use Low shrinkage component in face brick mixes.

Remarks: High absorption at all firing temperatures.

SAMPLE NO.: 30 FORMATION: Pleistocene COUNTY: Kent

Location: Ditch, 1/4 mile east of Road 434, NE Farmington.

Description: Tan and gray slightly sandy silt-clay.

Raw Properties:

Water of Plasticity, Percent 16.0 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 5.0 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	5.0	15.5	30.3	1.96
1900	Tan	3	5.0	12.5	24.8	1.98
2000	Tan	4	7.5	11.0	22.3	2.03
2100	Buff	5	10.0	8.6	18.0	2.09
2200	Brown	6	10.0	6.1	13.1	2.15
2300	Gray	6	10.0	3.8	8.2	2.15

Bloating Test Negative

Other Tests pH - 5.7. Not effervescent with HCl. Sand 74%, silt-clay 26%.

Clay minerals: kaolinite, illite.

Potential Use Face brick, structural tile.

Remarks: Should fire to "SW" face brick specifications at about 2100°F.

Might be glazed.

SAMPLE NO.: 31 FORMATION: Potomac COUNTY: New Castle

Location: Road 350, 1/2 mile east of Road 351, Newark

Description: Gray silt-clay interbedded with tan fine sand

Raw Properties:

Water of Plasticity, Percent 19.3 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 5.0 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	5.0	19.3	34.0	1.76
1900	Tan	2	5.0	17.2	31.0	1.80
2000	Tan	2	5.0	16.3	29.8	1.83
2100	Lt. brown	3	5.0	13.3	25.4	1.91
2200	Red-brown	4	10.0	9.0	18.5	2.06
2300	Gray-brown	5	10.0	3.9	7.9	2.02

Bloating Test Negative

Other Tests pH - 5.6. Not effervescent with HCl. Sand 24%, silt-clay 76%;
kaolinite, illite, vermiculite.

Potential Use Face brick

Remarks: Should fire to "SW" Face brick specifications at about 2200°F.

SAMPLE NO.: 32 FORMATION: Miocene COUNTY: Kent

Location: Highway 8, 1 mile east of Pearson's Corner

Description: Black clay

Raw Properties:

Water of Plasticity, Percent 32.9 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 5.0 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Beige	2	5.0	34.6	47.4	1.37
1900	Lt. brown	2	7.5	32.4	46.0	1.42
2000	Lt. brown	3	7.5	30.0	44.0	1.47
2100	Med. brown	4	10.0	24.8	38.9	1.57
2200	Dk. brown	5	12.5	20.7	33.7	1.63
2300	Dk. gray	6	12.5	13.9	22.1	1.59

Bloating Test Negative

Other Tests pH - 4.2. Not effervescent with HCl. Sand 74%, silt-clay 26%;
kaolinite, illite.

Potential Use Not suitable for use in vitreous clay products.

Remarks: High absorptions at all firing temperatures. Poor color.

SAMPLE NO.: 33 FORMATION: Miocene COUNTY: Kent

Location: Hollett's Corner, N. W. Kent County.

Description: Dark gray silt clay.

Raw Properties:

Water of Plasticity, Percent 23.9 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 5.0 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	5.0	20.9	35.1	1.68
1900	Tan	3	5.0	19.8	33.9	1.71
2000	Lt. brown	4	7.5	18.2	32.0	1.76
2100	Lt. brown	4	10.0	14.4	26.6	1.85
2200	Gray brown	5	12.5	9.4	18.4	1.96
2300	Gray green	6	15.0	6.8	12.0	1.77

Bloating Test Negative

Other Tests pH - 4.5. Not effervescent with HCl. Sand 19%. silt-clay 81%.

Clay minerals: kaolinite, illite.

Potential Use Face brick.

Remarks: Should fire to "MW" face brick specifications at about 2100°F.

Poor color.

SAMPLE NO.: 34 FORMATION: Miocene COUNTY: Kent

Location: Road 317, 1/2 mile south of Highway 9.

Description: Dark gray silt-clay.

Raw Properties:

Water of Plasticity, Percent 25.7 Working Properties Moderate plasticity

Drying Defects None Drying Shrinkage, Percent 5.0 Dry Strength Fair

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800	Tan	2	5.0	20.5	34.6	1.69
1900	Tan	3	7.5	16.1	29.3	1.82
2000	Lt. brown	4	10.0	12.9	24.6	1.91
2100	Lt. brown	5	12.5	9.5	18.7	1.96
2200	-	-	Expanded	-	-	-
2300	-	-	-	-	-	-

Bloating Test Positive

Other Tests pH -5.4. Not effervescent with HCl. Sand 46%, silt-clay 54%.

Clay minerals: kaolinite, illite.

Potential Use Face brick

Remarks: Should fire to "MW" face brick specifications at about 2000°F.

Poor color.

PRELIMINARY BLOATING TEST

SAMPLE NO.: 34

Crushing characteristics Angular

Particle size 3/4" lumps Retention time 15 minutes

Temp. °F	Percent absorption	Bulk density		Remarks
		gm/cc	Lb/ft ³	
1800				
1900				
2000				
2100	8.5	1.72	107	No expansion
2200	11.6	1.31	82	Slight expansion
2300	10.4	1.11	69	Fair pore structure

Comments Marginal raw material for lightweight aggregate (refractory).

SAMPLE NO.: 35 FORMATION: Marsh COUNTY: Kent

Location: Road 89, 1 1/2 miles south of Port Mahon.

Description: Very organic-rich, peaty brownish-gray mud.

Raw Properties:

Water of Plasticity, Percent 67.7 Working Properties Poor

Drying Defects None Drying Shrinkage, Percent 9.8 Dry Strength Excellent

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	2.5 YR 5/6	4	22.5	23.5		1.51
2100 B	2.5 YR 5/6	6	30.0	7.4		1.94
2200 C	2.5 YR 3/2	7+	--*	2.9		0.81
2300 D	5 YR 4/2	7+	--*	1.4		1.33

Bloating Test Positive

Other Tests Fatty texture. Presence of soluble salts has caused surface on edges

to fuse at 2000 and 2100°F., while center of clay is porous. D. S. psi 3.5":269.7.

*Fused (non-measurable) pitted, did not retain shape. Extruding properties good.
pH - 5.4. Clay minerals: kaolinite, illite, montmorillonite.

Potential Use Probable use in lightweight aggregate.

Remarks: Good firing range.

SAMPLE NO.: 36 FORMATION: Marsh COUNTY: Kent

Location: Highway 9, 2 miles south of Leipsic

Description: Brown, organic-rich mud.

Raw Properties:

Water of Plasticity, Percent 51.1 Working Properties Poor

Drying Defects None Drying Shrinkage, Percent 7.3 Dry Strength Poor

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	7.5 YR 6/4	1	10.5	48.1		1.11
2100 B	7.5 YR 5/4	1	13.8	37.9		1.23
2200 C	7.5 YR 4/2	5	17.9	21.9		1.52
2300 D	7.5 YR 5/2	6 1/2	--*	14.8		1.56

Bloating Test Negative

Other Tests Large quantity of sand and organic material present. Extruding proper-
ties are good. Sulfur odor. *Fused, non-measurable, retained shape. D. S. psi 3,5":
122.6. pH 4.5. Sand 34%, silt-clay 66%. Clay minerals: kaolinite, illite, vermiculite.

Potential Use None in structural clay products.

Remarks: _____

SAMPLE NO.: 37 FORMATION: Marsh COUNTY: Kent

Location: Road 349, 1 mile east of Highway 9.

Description: Brownish-gray organic-rich mud.

Raw Properties:

Water of Plasticity, Percent 15.7 Working Properties Fair

Drying Defects None Drying Shrinkage, Percent 0.3 Dry Strength Excellent

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	7.5 YR 8/6	1	0.3	18.1		1.75
2100 B	7.5 YR 7/6	3	1.3	16.9		1.77
2200 C	7.5 YR 7/4	5	2.5	13.3		1.82
2300 D	7.5 YR 6/4	6	2.5	13.7		1.84

Bloating Test Negative

Other Tests Very sandy texture, poor extruding properties. Suggest addition of vitrifying bonding material to improve workability and fired strength. Sulfur odor. Weeds and seeds present in sample. D. S. psi 3.5":179. pH - 6.3. Sand 74%, silt-clay 26%. Clay minerals: kaolinite, illite, chlorite and vermiculite.

Potential Use Possible use in brick and tile.

Remarks: _____

SAMPLE NO.: 38 FORMATION: Marsh COUNTY: Kent

Location: Highway 113 at St. James River.

Description: Brownish gray organic-rich mud.

Raw Properties:

Water of Plasticity, Percent 50.4 Working Properties Fair

Drying Defects None Drying Shrinkage, Percent 9.0 Dry Strength Excellent

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	5 YR 5/6	4	15.0	29.8		1.42
2100 B	5 YR 4/4	7	22.5	11.6		1.91
2200 C	5 YR 4/2	7+	20.8	10.1		1.46
2300 D	5 YR 5/2	7+	--*	13.6		1.17

Bloating Test Positive

Other Tests Starts to bloat at 2200°F. Extruding properties are good. Large quantity of organic material present. *Fused, non-measurable, starts to lose shape. D.S. psi 3.5"; 251.4. Sand 48%, silt-clay 52%. pH 5.6. Clay minerals: kaolinite, illite, chlorite and vermiculite.

Potential Use Possible use as a component in B and T. Expansion indicates possible use as a lightweight aggregate.

Remarks: _____

CLAY EVALUATION: ROTARY KILN TEST

SAMPLE NO.: 38

RAW MATERIAL

Screen Analysis: (Crushed through 1" jaws and 3/4" rollers)

<u>Through</u>	<u>Retained on</u>	<u>Weight, percent</u>	<u>Cumulative, percent</u>
3/4"	1/2"	21.64	21.64
1/2"	4-mesh	30.61	52.52
4-mesh	8-mesh	14.51	66.76
8-mesh		33.24	100.00

Comments: +3/4" 36.62% of total crushed material. Blocky fragments.

Total weight dry material 59.8 lb. Very wet, dried in oven.

Firing Data:

Size range of feed -3/4+8 mesh Pour weight of feed 45.40 pcf

Bloating temperature 2150°F Logging temperature * 2250°F
(*Nodules sticking together.)

FIRED MATERIAL

(All fired material crushed through roll crusher)

Screen Analysis: *(Percentages by weight passing sieves)

Size designation:	<u>3/4"</u>	<u>1/2"</u>	<u>No. 4</u>	<u>No. 8</u>	<u>No. 16</u>	<u>No. 50</u>	<u>No. 100</u>
Fine aggregate:	-	100	33.42	7.46	2.13	1.20	1.07
Coarse aggregate:	100	75.58	24.16	4.11	-	-	-

Loose Pour Weights:*

Fine aggregate: 43.18 pcf

Coarse aggregate: 42.15 pcf

*ASTM Designation C 331-59T.

Comments: Partially logged. Fair pore structure. Good crush strength and quench resistance. Color brown. Clay indurated at 2100°F may also be good aggregate --higher pour weight.

SAMPLE NO.: 39 FORMATION: Marsh COUNTY: Sussex

Location: Highway 36 at Cedar Beach

Description: Brownish gray organic-rich mud.

Raw Properties:

Water of Plasticity, Percent 54.0 Working Properties Fair

Drying Defects None Drying Shrinkage, Percent 7.5 Dry Strength Good

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	2.5 YR 7/6	1	10.0	42.5		1.21
2100 B	2.5 YR 5/4	3	16.7	30.9		1.39
2200 C	2.5 YR 2/2	7	--*	10.7		1.24
2300 D	2.5 YR 4/2	7+	--*	12.9		1.13

Bloating Test Positive

Other Tests Bloated at 2200°F., extruding properties are good. Large quantity of organic material present. *Fused, non-measurable, starts to lose shape. D. S.

psi 3.5": 235.7. pH 6.0. Sand 5%, silt-clay 95%. Clay minerals: kaolinite, illite, chlorite, and vermiculite.

Potential Use Expansion indicates possible use in lightweight aggregate.

Remarks: _____

CLAY EVALUATION: ROTARY KILN TEST

SAMPLE NO.: 39

RAW MATERIAL

Screen Analysis: (Crushed through 1" jaws and 3/4" rollers)

<u>Through</u>	<u>Retained on</u>	<u>Weight, percent</u>	<u>Cumulative, percent</u>
3/4"	1/2"	31.90	31.90
1/2"	4-mesh	29.85	61.75
4-mesh	8-mesh	14.88	76.63
8-mesh		23.37	100.00

Comments: +3/4" 12.88% of total crushed material. Blocky fragments.

Total weight dry material 246.1 lb. Very wet, dried in oven.

Firing Data:

Size range of feed -3/4+8 mesh Pour weight of feed 44.52 pcf

Bloating temperature 2150°F Logging temperature * 2250°F
(*Nodules sticking together)

FIRED MATERIAL

(All fired material crushed through roll crusher)

Screen Analysis: *(Percentages by weight roll crusher)

Size designation:	<u>3/4"</u>	<u>1/2"</u>	<u>No. 4</u>	<u>No. 8</u>	<u>No. 16</u>	<u>No. 50</u>	<u>No. 100</u>
Fine aggregate:	-	100	45.85	14.40	3.28	1.55	1.28
Coarse aggregate:	100	64.36	28.33	7.40	-	-	-

Loose Pour Weights: *

Fine aggregate: 45.02 pcf

Coarse aggregate: 44.78 pcf

*ASTM Designation C 331-59T.

Comments: Aggregate partially logged.
Fair pore structure. Good crush strength and quench resistance.
Brown color. Clay indurated at 2100°F may also be a good aggregate.

SAMPLE NO.: 40 FORMATION: Marsh COUNTY: Sussex

Location: Road 258 at Broadkill River

Description: Brownish gray organic-rich mud.

Raw Properties:

Water of Plasticity, Percent 52.9 Working Properties Fair

Drying Defects None Drying Shrinkage, Percent 8.8 Dry Strength Excellent

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	5 YR 7/6	5	15.0	29.6		1.45
2100 B	5 YR 6/6	6 1/2	22.5	12.3		1.84
2200 C	2.5 YR 4/2	7+	--*	8.9		1.68
2300 D	2.5 YR 4/2	7+	--	7.4		1.50

Bloating Test Positive

Other Tests Slight bloat at 2200°F. Extruding properties are good. Sulfur odor.

Germinating seed present, much organic material. *Fused, pitted (non-measurable)

retained shape. D. S. psi 3.5"; 306.8. pH 4.0. Sand 24%, silt-clay 76%. Clay minerals: kaolinite, illite, chlorite and vermiculite.

Potential Use Possible use as a component in B and T.

Remarks: _____

SAMPLE NO.: 41 FORMATION: Potomac COUNTY: New Castle

Location: Road 391, 1 mile south of Road 396; Chesapeake & Delaware Canal.

Description: Variegated gray and orange sandy clay.

Raw Properties:

Water of Plasticity, Percent 18.2 Working Properties Excellent

Drying Defects None Drying Shrinkage, Percent 4.0 Dry Strength PSI 487

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	5 YR 7/6	3	5.0	13.3		1.79
2100 B	5 YR 5/6	4	5.0	10.8		1.87
2200 C	5 YR 4/4	7	5.3	9.5		2.00
2300 D	2.5 YR 4/4	7+	6.3	9.5		2.03

Bloating Test Negative

Other Tests Extruding properties are good. Good color range. pH 6.0.

Sand 52%, silt-clay 48%. Clay minerals: kaolinite, illite.

Potential Use Probable use as sole ingredient in most structural clay products,
including S. P. Probable use in stoneware industry.

Remarks: "S. P." is sewer pipe.

SAMPLE NO.: 42 FORMATION: Potomac COUNTY: New Castle

Location: 1.4 miles south of Road 396 on Road 391, Chesapeake and Delaware Canal

Description: Slightly reddish gray sandy clay.

Raw Properties:

Water of Plasticity, Percent 23.1 Working Properties Good

Drying Defects None Drying Shrinkage, Percent 4.3 Dry Strength PSI 262

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
	10 YR					
2000 A	9/2	1	4.8	16.8		1.66
	10 YR					
2100 B	8/4	3	4.8	15.3		1.67
	10 YR					
2200 C	8/4	5	5.3	14.9		1.81
	10 YR					
2300 D	8/2	6	6.8	13.3		1.83

Bloating Test Negative

Other Tests Extruding properties are good. Suggest P. C. E. to determine refractory

classification. The addition of a bonding clay would increase hardness and reduce

absorption. pH 5.9. Sand 15%, silt-clay 85%. Clay minerals: kaolinite, illite,
vermiculite.

Potential Use Possible use in most structural clay products except S. P. if hardness is
improved. Possible use in refractory brick. Probable use as low shrinkage in-
gredient in stoneware industry.

Remarks: _____

SAMPLE NO.: 43 FORMATION: Pleistocene COUNTY: Sussex

Location: Road 78, 1/2 mile north of Woodland Ferry.

Description: Dark gray silty clay.

Raw Properties:

Water of Plasticity, Percent 29.8 Working Properties Excellent

Drying Defects None Drying Shrinkage, Percent 7.5 Dry Strength PSI 456

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	7.5 YR 7/4	3	8.8	17.7		1.69
2100 B	7.5 YR 6/4	6	8.8	14.4		1.74
2200 C	7.5 YR 5/4	7+	12.8	11.9		1.94
2300 D	7.5 YR 5/2	7+	12.0	8.7		1.97

Bloating Test Negative

Other Tests Very slight bloat at 2300°F. Extruding properties are good.

Excellent color range. pH - 6.0. Sand 9%, silt-clay 91%. Clay minerals: kaolinite, illite, vermiculite.

Potential Use Probable use as sole ingredient in B and T. Possible use in stoneware industry.

Remarks: _____

SAMPLE NO.: 44 FORMATION: Pleistocene COUNTY: Sussex

Location: Riverside Drive, .2 miles west of Highway 13, Seaford.

Description: Light gray silty clay.

Raw Properties:

Water of Plasticity, Percent 38.5 Working Properties Excellent

Drying Defects None Drying Shrinkage, Percent 10.0 Dry Strength 750 psi

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900						
2000 A	7.5 YR 7/8	7	12.5	12.2		1.85
2100 B	7.5 YR 5/6	7+	15.0	5.2		2.07
2200 C	2.5 YR 4/4	7+	15.8	4.3		2.19
2300 D	5 YR 4/4	7+	16.5	3.4		2.23

Bloating Test Negative

Other Tests Excellent color range. Extruding properties are good. Severe cracking upon cooling. Addition of a non-plastic grog would improve total shrinkage and reduce cracking. pH - 5.9. Sand 73%, silt-clay 27%; kaolinite, illite.

Potential Use Probable use in B and T.

Remarks: _____

SAMPLE NO.: 45 FORMATION: Pleistocene COUNTY: Sussex

Location: Intersection Roads 231, 212; Milton.

Description: Sandy silt.

Raw Properties:

Water of Plasticity, Percent 20.0 Working Properties Meally - gritty

Drying Defects None Drying Shrinkage, Percent 3.6 Dry Strength PSI 202

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900 A	7.5 YR 8/6	2.0	4.3	17.1		1.84
2000 B	7.5 YR 7/6	2.5	4.2	15.7		1.87
2100 C	5 YR 7/6	3.0	4.2	14.3		1.90
2200 D	5 YR 6/6	3.5	5.4	12.3		1.99
2300						

Bloating Test Negative

Other Tests No defects -- gritty and meally; extrudes fair. CaCO₃ negative.

Suggest the addition of a more plastic clay to improve workability, hardness and
reduce the absorption. pH - 5.8. Sand 26%, silt-clay 74%.

Potential Use Possible use as a non-plastic filler clay in B and T. Possible use
in porous clay products if hardness is improved.

Remarks: _____

SAMPLE NO.: 46 FORMATION: Miocene (?) COUNTY: Kent

Location: Highway 9, 2 1/2 miles north of Leipsic.

Description: Clayey silt, gray and tan.

Raw Properties:

Water of Plasticity, Percent 22.6 Working Properties Good

Drying Defects None Drying Shrinkage, Percent 4.1 Dry Strength PSI 297

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900 A	7.5 YR 8/6	2.5	4.2	16.4		1.80
2000 B	7.5 YR 6/6	3.0	5.1	14.3		1.88
2100 C	5 YR 5/6	3.5	6.4	12.5		1.93
2200 D	5 YR 4/6	5.0	8.6	6.9		2.12
2300						

Bloating Test Negative

Other Tests No defects--extrudes well. CaCO₃ negative. Good color range. Suggest addition of a better bonding material to improve hardness. pH - 6.0. Sand 66%, silt, 34%.

Potential Use Probable use as a component in most structural clay products, including S. P. Possible use in porous clay products if hardness is improved.

Remarks: _____

SAMPLE NO.: 47 FORMATION: Pleistocene COUNTY: Sussex

Location: Intersection Roads 487, 490; South of Seaford.

Description: Khaki and gray silty clay.

Raw Properties:

Water of Plasticity, Percent 22.9 Working Properties Excellent

Drying Defects None Drying Shrinkage, Percent 4.6 Dry Strength PSI 436

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900 A	7.5 YR 7/6	3	5.9	12.2		1.91
2000 B	5 YR 6/8	4	8.2	8.8		2.06
2100 C	5 YR 5/6	4.5	8.9	6.1		2.13
2200 D	2.5 YR 4/6	5.0	10.4	2.0		2.26
2300						

Bloating Test Negative

Other Tests No defects--extrudes well. CaCO₃ negative. Good color range.

pH - 6.7. Sand 66%, silt-clay 34%. Clay minerals: kaolinite, illite.

Potential Use Probable use as sole component in most structural clay products
including S. P. Probable use in the domestic stoneware and earthenware industries.
Excellent color for common red brick.

Remarks: _____

SAMPLE NO.: 48 FORMATION: Weathered Pegmatite COUNTY: New Castle

Location: Highway 72, .9 miles north of Milford Crossroad.

Description: Iron stained pegmatitic clays.

Raw Properties:

Water of Plasticity, Percent 36.2 Working Properties Short, fair plasticity

Drying Defects None Drying Shrinkage, Percent 6.0 Dry Strength PSI 272

Slow Firing Test:

Temp. °F	Color	Moh's Hardness	Percent Total Shk.	Percent Abs.	Percent App. Por.	Bulk Dens. gm/cc
1800						
1900 A	5 YR 6/6	2.0	8.2	25.7		1.58
2000 B	5 YR 5/6	2.5	11.2	20.4		1.69
2100 C	5 YR 5/4	3.0	11.0	21.4		1.73
2200 D	2.5 YR 4/6	3.5	12.4	20.2		1.83
2300						

Bloating Test Negative

Other Tests No defects--short--extrudes fair. CaCO₃ slightly positive. Suggest the addition of a better bonding clay to improve hardness and reduce absorption.

pH - 6.3. Sand 66%, silt-clay 34%. Clay minerals: kaolinite.

Potential Use Possible use as a non-plastic filler in structural clay products.

Remarks: _____

QUICK-FIRING TEST

Retention time, Min: 15

Temperature °F.

Sample No.		1900	2000	2100	2200	2300
35	Weight lb/cu ft.		129.8	78.0	55.5	-
	Absorption percent		36.8	44.0	21.6	-
36	Weight lb/cu ft.		106.7	124.2	82.4	-
	Absorption percent		24.5	23.3	10.1	-
37	Weight lb/cu ft.		141.0	149.8	155.4	146.0
	Absorption percent		18.4	16.3	11.2	10.2
38	Weight lb/cu ft.		142.3	120.4	101.1	-
	Absorption percent		24.4	23.2	5.0	-
39	Weight lb/cu ft.		135.4	140.4	104.2	-
	Absorption percent		31.3	20.9	9.7	-
40	Weight lb/cu ft.		135.4	135.4	118.6	-
	Absorption percent		35.1	22.7	7.2	-
41	Weight lb/cu ft.		126.7	122.9	126.7	131.7
	Absorption percent		9.9	9.9	8.9	4.7
42	Weight lb/cu ft.		114.8	112.9	114.8	122.9
	Absorption percent		14.2	13.7	12.2	9.0
43	Weight lb/cu ft.		123.6	123.6	131.7	116.1
	Absorption percent		9.6	9.0	5.6	3.9
44	Weight lb/cu ft.		131.7	138.5	137.9	151.6
	Absorption percent		6.7	5.6	3.9	1.7
45	Weight lb/cu ft.	110.4	121.1	121.1	121.1	
	Absorption percent	16.4	17.0	16.0	14.9	
46	Weight lb/cu ft.	98.6	99.2	99.2	99.2	
	Absorption percent	21.6	23.6	23.6	22.5	
47	Weight lb/cu ft.	118.6	117.9	131.0	131.7	
	Absorption percent	15.3	13.8	10.6	7.9	
48	Weight lb/cu ft.	72.4	88.6	96.7	97.3	
	Absorption percent	36.0	33.5	26.3	27.9	

SUMMARY OF DATA

Fired samples of clay mentioned in this report are on open file at the Delaware Geological Survey.

The data sheets show that Delaware clay may be useful for various types of clay products. However, it should be kept in mind that the tests are preliminary, and that a pilot operation should be made before establishing a clay processing plant.

Table 1 shows the summary of data. Table 2 defines terms.

Samples 6, 8, 19, 21, 30, 31, 33, 34, 37, 43, 44 and 47 appear to be promising for brick making. Samples 3, 4, 5, 7, 17 and 18 are marginal and may also produce good bricks. Low dry strength is the principal fault of clays which did not test as "very good." The samples from which bricks may be produced are mostly from the Potomac Formation of north central New Castle County. Almost any exposure of Potomac clays could be considered a potential site for a brick plant. The area around I-95 near Basin Road looks particularly good. Where it is not exposed in north central New Castle County, the Potomac is overlain frequently by only a few feet of Pleistocene sand and gravel which could be easily removed. Two Miocene clays (33, 34) and two Pleistocene clays (30, 47) also appear to be promising for bricks. The Miocene clays are in northern Kent County, and the Pleistocene ones in southwestern Kent (30) and south of Seaford (47).

Samples 11 and 35 appear to be most promising for lightweight aggregate. These are both modern coastal marsh organic-rich clays. Samples 9, 10, 16, 23, 34, 38 and 39 are marginal for lightweight aggregate. These are also marsh "mucks" except for 23 which is from the Cretaceous marine Englishtown Formation.

Samples 1 and 30 appear to be useful for glazed tile. Number 1 is from the Potomac Formation and Number 30 from the Pleistocene Staytonville unit in Sussex County.

At least two New Castle County Potomac samples, 21 and 41, are promising for the manufacture of sewer pipe. Samples 46 and 47 (Miocene and Pleistocene) are also promising for sewer pipe. Sample 46 comes from the Leipsic area, and Number 47 from the Seaford area.

Samples 41 and 42 from the Potomac Formation, and 43, 46 and 47 from the Columbia Formation are possible raw materials for use in the stoneware industry. In addition, Sample 42 is promising for refractory bricks.

A number of samples appear to be useful for low shrinkage components in face brick mixtures. These are 20, 22, 24, 25, 26, 27, 28 and 29.

Table 1. Summary of Data
(Sample Numbers)

<u>Brick</u>		<u>Lightweight Aggregate</u>		<u>Glazed Tile</u>	<u>Sewer Pipe</u>	<u>Stoneware</u>
<u>Promising</u>	<u>Marginal</u>	<u>Promising</u>	<u>Marginal</u>	<u>Promising</u>	<u>Promising</u>	<u>Promising</u>
6	3	11	9	1	21	41
8	4	35	10	30	41	42
19	5		16		46	43
21	7		23		47	46
30	17		24			47
31	18		38			
33			39			
34						
37						
43						
44						
47						

Table 2. Glossary of Terms

BLOATED	. Expanded with a porous structure.
B and T	. Brick and tile.
D. S.	. Mechanical strength of clay dried but not fired.
FACE BRICK	. Brick especially selected for face of a wall.
GREEN STRENGTH	. Strength of unfired clay.
GROG	. Burned clay added to clay mixture.
LOGGED	. Clay partially melts and is sticky.
MW BRICK	. Capable of withstanding "moderate weather" with little frost action.
P. C. E.	. Pyrometric cone equivalent.
P. C. F.	. Pounds per cubic foot.
POUR WEIGHT	. Weight of fired rotary kiln sample.
REFRACTORY	. Material with high melting point.
S. C. P.	. Structural clay products.
S. P.	. Sewer pipe.
SW BRICK	. Capable of withstanding "severe weather" with a lot of frost action.
VITRIFICATION	. Process of making glassy.

Therefore, it is apparent that Delaware clays have the potential for use in a number of ceramic products. Clays for bricks seem to be the most common, and clays for lightweight aggregate are also quite important. The Potomac Formation is best for brick manufacture, and the modern coastal marsh organic-rich, "mucky" clays appear to be best for lightweight aggregate production in Delaware.

Three samples were roasted in a rotary kiln to provide data from larger samples (500 pounds). These samples are 11, 38, 39. These tests further indicate that the coastal marshes may be useful sources of bloatable clays for lightweight aggregate products.

LIGHTWEIGHT AGGREGATE

Lightweight aggregate is fired, vesicular, expanded clay which is used predominantly in concrete where low bulk density is desired. This type of concrete is finding increased use in construction of the framework, walls, and roofs of large buildings and for a variety of prefabricated concrete building units. The most desired property is strength with lightness. The desired bulk density for expanded clay is from 40-60 pounds per cubic foot (Miles Tyrrell, personal communication).

There has been some indication that crushed lightweight aggregate may be useful as a skid-resistant additive in highway surfaces. The hard, vesicular fired clay always presents a rough surface even after parts have been broken away.

Large commercial lightweight aggregate plants exist in the United States; however, none exists in the Mid-Atlantic region. Delaware marsh clays appear to have the potential to supply some lightweight aggregate for this area.

REFERENCES

- Diamond, W. G., Early, T. R., and Robertson, H. F., 1964, Expanded clay and shale lightweight aggregate industry in the south central United States: U. S. Bureau Mines Info. Circ. 8233, 50 p.
- Grosh, W. A., and Hamlin, H. P., 1963, Lightweight aggregate - expansion properties of clays, shales, and argillites of Minnesota: U. S. Bureau Mines Rept. Invest. 6313, 30 p.
- Hamlin, H. P., and Templin, G., 1962, Evaluating raw materials for rotary kiln production of lightweight aggregate: U. S. Bureau Mines Info. Circ. 8122, 23 p.
- Jordan, R. R., 1962, Stratigraphy of the sedimentary rocks of Delaware: Delaware Geol. Survey Bull. 9, 51 p.
- Klinefelter, T. A., and Hamlin, H. P., 1957, Syllabus of clay testing: U. S. Bureau Mines Bull. 565, 67 p.
- Knechtel, M. M., and others, 1961, Physical properties of the nonmarine Cretaceous clays in the Maryland Coastal Plain: Maryland Dept. Geol., Mines, and Water Resources Bull. 23, 11 p.
- Knechtel, M. M., Hamlin, H. P., Hostermann, J. W., 1966, Expandable clay in St. Marys Formation of southern Maryland: Maryland Geol. Survey Rept. of Invest. No. 4, 17 p.
- Miller, W. T., and Hamlin, H. P., 1964, Examining and testing clays from Hartford County, Connecticut, for lightweight aggregate use: U. S. Bureau Mines Info. Circ. 8228, 21 p.
- Munsell Soil Color Charts, 1954, Munsell Color Co., Inc.
- O'Neill, B. J., Jr., Lapham, D. M., Jaron, M. G., Socolow, A. A., Thomson, R. P., Hamlin, H. P., 1965, Properties and uses of Pennsylvania shales and clays: Pennsylvania Geol. Survey, 4th Ser. Bull. M 51, 448 p.
- Pallister, H. D., Hastings, E. L., Daniel, T. W., 1964, Clay and shale for lightweight aggregate in Alabama: Alabama Geol. Survey Circ. 26, 45 p.

