STATE OF ARKANSAS

# Arkansas Geological Survey

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Acting State Geologist

BULLETIN 7

# KAOLIN DEPOSITS of SOUTHERN PIKE COUNTY, ARKANSAS

By

Paul G. Herold and George R. Heyl

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## LETTER OF TRANSMITTAL

ARKANSAS GEOLOGICAL SURVEY

Little Rock, Arkansas, June 22, 1942

Hon. Homer M. Adkins,
Governor, State of Arkansas,
Little Rock, Arkansas.

Sir:

I have the honor to submit herewith Bulletin 7, "Kaolin Deposits of Southern Pike County, Arkansas," by Paul G. Herold and George R. Heyl.

Because the kaolin deposits of Pike County consist of an unusual, pure type of clay, they were considered worthy of a special investigation. The results of this study are set forth in this publication. The several tests indicate that the Pike County kaolin considered is desirable for the manufacture of vitreous whiteware in those cases in which white color, minimum warpage, and considerable dry strength are the important factors, and that Pike County kaolin can be substituted for Florida plastic kaolin in most ceramic bodies.

It is hoped that the results of this investigation may encourage the development of a local ceramic industry in Pike County or vicinity.

Respectfully submitted,

Richard J. Anderson

Acting State Geologist.

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# KAOLIN DEPOSITS OF SOUTHERN PIKE COUNTY, ARKANSAS

By Paul G. Herold and George R. Heyl

## ABSTRACT

Chalky white to cream colored kaolin is found in the Tokio formation (Upper Cretaceous) in the hilly, wooded region between Murfreesboro and Delight, Pike County, Arkansas. The kaolin occurs as horizontal beds which range up to five feet in thickness. In places these deposits have been prospected, and from one of these pits a sample of kaolin was obtained. This sample was subjected to certain physical and ceramic tests which indicate that the clay is suitable for the manufacture of vitreous whiteware, particularly in those cases in which white color, minimum warpage, and considerable dry strength are the important factors.

## INTRODUCTION

Clay is a mixture of hydrous aluminum silicates, plastic when moistened, and permanently hard when baked or fired. Many clays, in addition to the hydrous aluminum silicates, contain as contaminations in large or small amount various minerals, such as quartz, feldspar, or mica. Some white clays of unusually high purity, which can be fired without discoloration, are known as kaolin.

Clay results from the decomposition of granite, syenite, and other feldspathic rocks. If the clay is found in place as formed, it is known as a residual clay. If it has been transported by streams and re-deposited in beds, it is known as a sedimentary clay.

## GEOLOGY

In the hilly, wooded region between Delight and Murfreesboro in southwestern Arkansas, deposits of kaolin are found in Upper Cretaceous strata near the northern edge of the Gulf Coastal Plain. The kaolin is present as one or more approximately horizontal beds, ranging in thickness from 64 inches to 18 inches or less. It occurs as interbeds in the Tokio formation, which is composed largely of sand and gravel, with lesser amounts of clay. The Tokio formation forms the greater portion of the interstream areas between Murfreesboro and Delight, and the kaolin beds are generally found in the higher parts of these areas.

The kaolin is chalky white to cream in color, with some thin layers of distinct lavender hue. The material is fine-grained, has a conchoidal fracture, and on close examination shows distinct bedding structures. In places, fragments of fossil plants may be found along the bedding planes in the kaolin. At some of the exposures, thin films of brown iron oxide have been deposited along the joint and bedding surfaces. Ross, Miser, and Stephenson[1] consider these beds of kaolin to be water laid volcanic material, originally feldspathic, altered to a very pure clay.

The kaolin beds have been prospected by pits and trenches in several places in southern Pike County. The locations of these prospects are shown on the accompanying map (Plate I).

[1]Ross, C. S., Miser, H. D., and Stephenson, L. W., Water-laid Volcanic Rocks of Early Upper Cretaceous Age in Southwestern Arkansas, Southeastern Oklahoma, and Northeastern Texas; U. S. Geol. Survey Prof. Paper 154-f, p. 186, 1928.

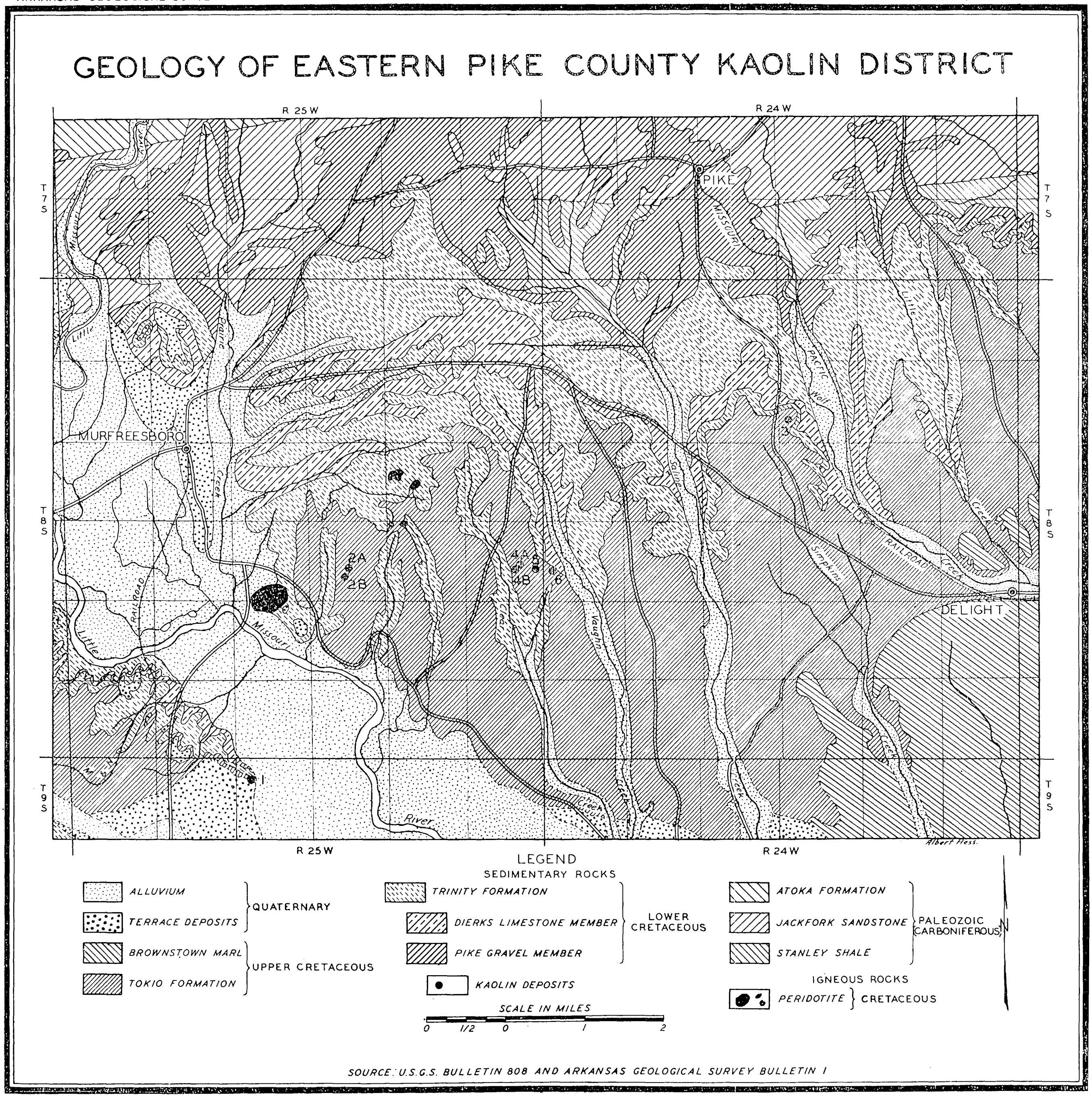



Plate I. Geology of eastern Pike County kaolin district

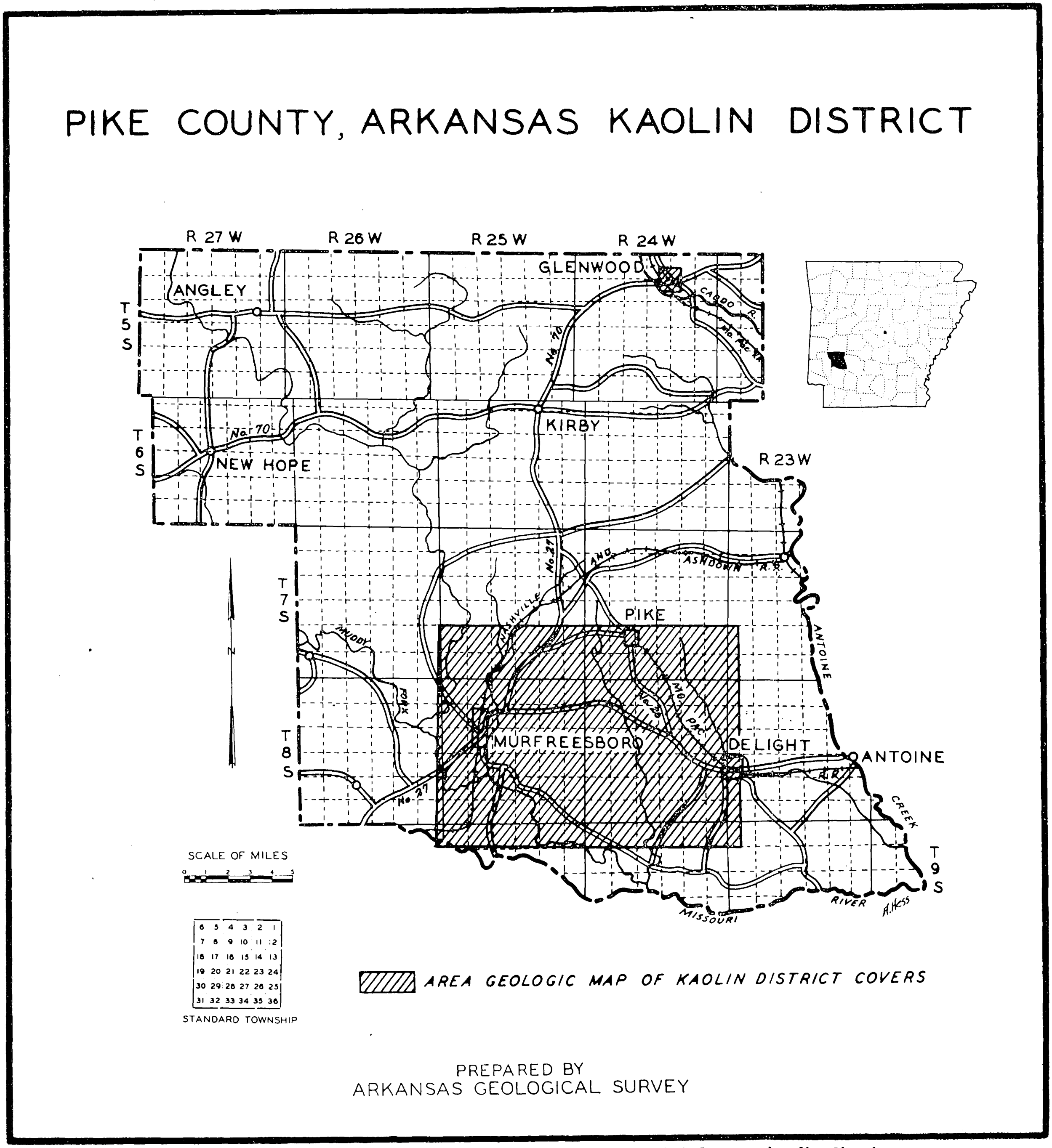



Plate II. Index map of Pike County, showing position of Arkansas kaolin district

*Stanley Prospect.* The Stanley prospect is located in the NW¼ SW¼ sec. 4, T. 9 S., R. 25 W., about 1.4 miles southeast of the village of Roy. This prospect consists of a shallow pit, about 6 feet across, which has been dug into the hill slope that bounds Cypress Slough on the north. The section exposed in the pit is shown diagrammatically in Plate II-1. Twenty-seven inches of kaolin are present. At the exposed face much of the kaolin is stained red-brown and yellow-brown by iron oxide. The kaolin may be expected to occur as an approximately horizontal bed under the highland immediately to the north of the pit. It is estimated that at least 1,900 tons of kaolin are present at this locality. The overburden in the vicinity of the pit ranges from 3 to 25 feet in thickness.

*Twin Knobs Prospect.* The Twin Knobs prospect is situated close to the center of sec. 22, T. 8 S., R. 25 W., approximately 2.6 miles southeast of Murfreesboro. At this locality the kaolin is limited to two restricted areas covering the summit areas of the Twin Knobs, the larger area being on the northern hill. The northern area falls in the NW¼ SE¼ of sec. 22, and the southern area in the NE¼ SW¼ of sec. 22.

On the south slope of the north knob, near its summit, a pit about 30 feet long and 25 feet wide has been excavated. The section exposed in this pit is shown diagrammatically in Plate II-2. The upper surface of the kaolin in this pit is somewhat irregular, but approximately 64 inches of the clay is exposed, the upper eight inches being thin-bedded buff and white kaolin strongly stained with iron oxide, the remaining 56 inches being white kaolin with irregular zones of buff kaolin. The kaolin underlies an area of approximately 22,000 square feet, and an estimated 5,000 tons are present. The thickness of overburden at this deposit ranges between 2½ and 20 feet.

On the south knob no pits exposed the clad bed, but small fragments of kaolin in the soil disclose its presence. J. K. Rankin of Nashville, who in 1938 sank a test pit, states that 2½ feet of kaolin are present. On the basis of this thickness, it is estimated that 1,000 tons are present. The overburden on the south hill is but a few feet thick.

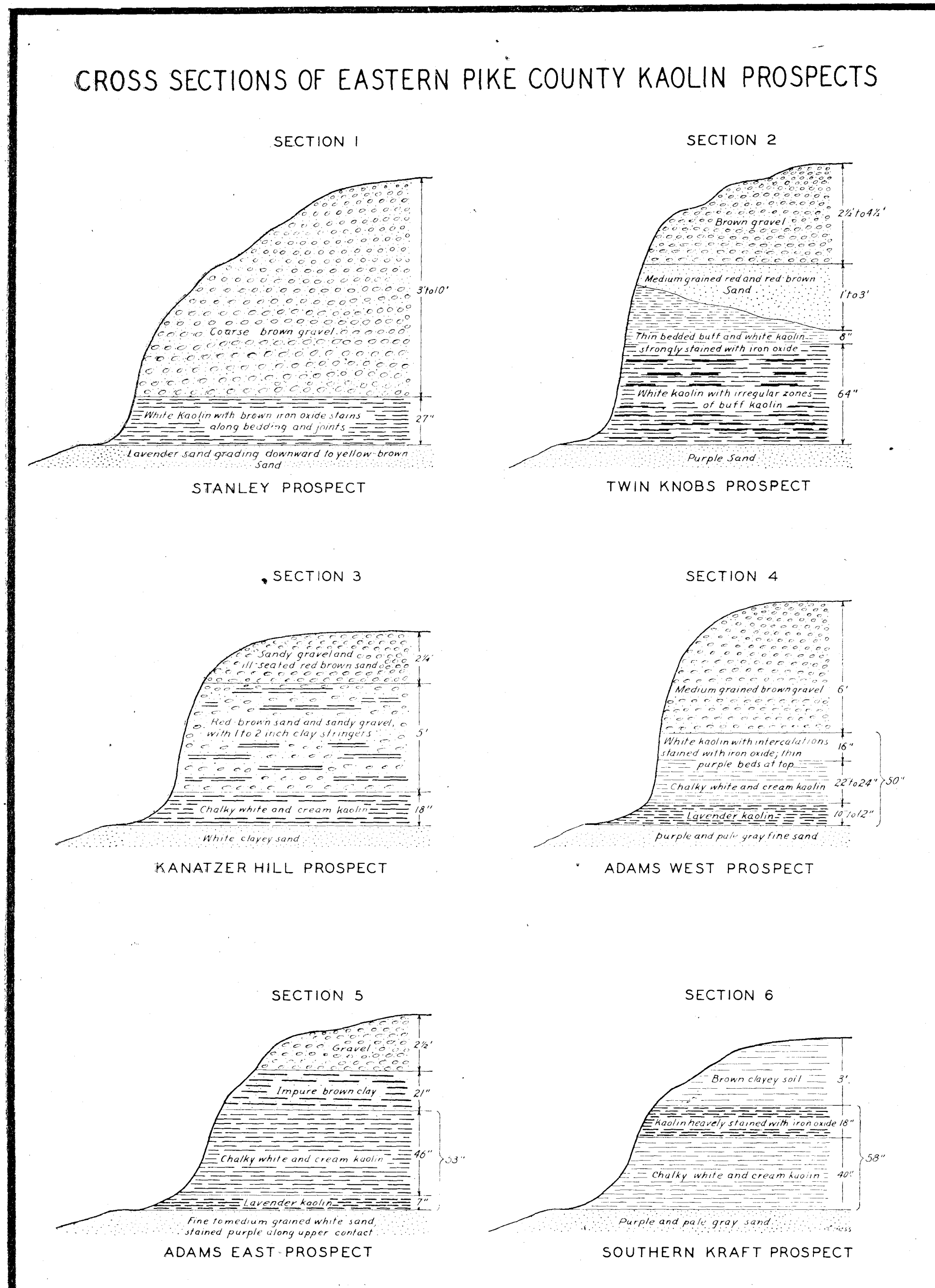


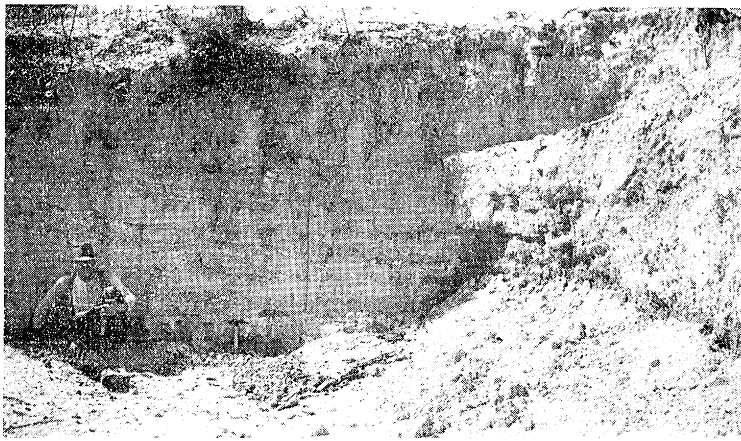

**Plate III. Cross sections of eastern Pike County kaolin prospects**

1. Stanley prospect
2. Twin Knobs prospect
3. Kanatzer Hill prospect
4. Adams west prospect
5. Adams east prospect
6. Southern Kraft prospect

*Kanatzer Hill Prospect.* The Kanatzer Hill prospect is located in the SW¼ SW¼ sec. 10, T. 8 S., R. 24 W., about 3.6 miles northwest of Delight. A pit 25 feet long and 20 feet wide has been excavated in the hillside about 150 yards east of the church on Kanatzer Hill. Near the floor of this pit an 18-inch bed of white kaolin is exposed. This is underlain by white clayey sand and overlain by red-brown sand, and sandy gravel with thin clay stringers. The section exposed in this pit is shown in Plate II-3. It is estimated that at least 2,400 tons of kaolin are present in this deposit.

**The kaolin pit on Kanatzer Hill, as viewed from the south.**

*Adams West Prospect.* The Adams West prospect lies close to the summit of the wooded divide between Clear Creek and Vaughn Creek in the NW¼ SE¼ sec. 24, T. 8 S., R. 25 W. At this locality two trenches have been opened in the hillsides, and several pits sunk in the vicinity. In the deeper of the trenches 50 inches of kaolin are exposed. The greater portion of the kaolin is chalky white and cream in color, but the basal 10 to 12 inches has a distinct lavender hue, and the upper 16 inches contains intercalations stained brown with iron oxide and a few thin purple beds at the top. The detailed section exposed in this trench is shown in Plate II-4. It is estimated that at least 20,000 tons of kaolin are present at the Adams West prospect. The overburden ranges in thickness from 3 feet in some of the pits to more than 30 feet in the highest adjacent hills.



**View of wall of pit on Kanatzer Hill. Eighteen inches of kaolin are exposed near the base of the face. The top of the kaolin bed is marked by the head of the hammer in the photograph.**

*Adams East Prospect.* About 1,000 feet to the east of the Adams West prospect described above, there is another group of pits which fall in the NE¼ SE¼ sec. 24, T. 8 S., R. 24 W. This is known as Adams East prospect. In the largest opening, a shallow barrow pit about 30 feet across, 53 inches of kaolin are exposed, the basal 7 inches being lavender in color, the remainder cream or white. The section exposed in this pit is shown in Plate II-5. It is estimated that at least 25,000 tons of kaolin are present at this prospect. The overburden ranges in thickness from 1 to 30 feet.

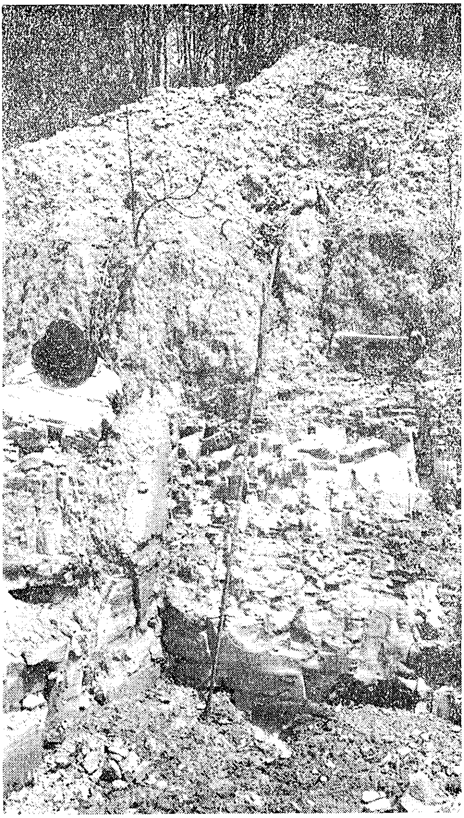
**The Adams East kaolin prospect, viewed from the south.**

*Southern Kraft Prospect.* Approximately 1,100 feet east of the Adams East prospect, on the eastern slope of the Clear Creek-Vaughn Creek divide, kaolin is exposed in several shallow pits which are known as the Southern Kraft prospect. At this locality, which falls in the NW¼ SW¼ sec. 19, T. 8 S., R. 24 W., the kaolin is restricted to the summit area of a small knoll. On the southern slope of this hill, a shallow pit has been opened which exposes 58 inches of kaolin. The upper 18 inches of the clay is heavily stained with iron oxide. The section exposed in this pit is shown diagrammatically in Plate II-6. The kaolin underlies an area of approximately 21,000 square feet, and an estimated 4,000 tons are present. The overburden ranges from 3 to 15 feet in thickness.

View of the large pit at the Adams East prospect. The kaolin bed is well exposed in this pit, and may be seen to the right of the hat in the photograph.

*Other occurrences.* In the well of his farmhouse in the S½ SW¼ sec. 32, T. 8 S., R. 24 W., P. Buster reports that a 10-foot bed of white clay was penetrated. This well is about 45 feet deep, and the clay bed was penetrated close to its bottom.

Several residents of sec. 9, T. 8 S., R. 24 W., report that a 2-foot bed of white kaolin was penetrated in the digging of shallow wells in the southeastern part of the section. These wells lie a short distance west and southwest of Kanatzer Hill.



**Close view of the wall of the large pit at the Adams East prospect. The hammer marks the top of the kaolin bed, which is 55 inches thick at this locality.**

## PHYSICAL AND CHEMICAL INVESTIGATION

A chemical analysis, certain physical tests, and a petrographic examination were made of the Pike County kaolin obtained from the pit on Kanatzer Hill in the SW¼ SW¼ sec. 10, T. 8 S., R. 24 W.

In order to form a basis of comparison, several typical whiteware clays commonly used in the ceramic industry have been included in this investigation. These clays are listed in Table 1, along with their petrographic analyses. All of the samples, with the exception of the Pike County and Delaware kaolins, were washed during processing to remove most of the impurities.

## TABLE 1. PETROGRAPHIC ANALYSES

| Clay | Description |
|---|---|
| Pike County kaolin | Grain size, medium. The clay contains a very small amount of quartz (0.2 per cent). Dehydration tests indicate that the chief clay mineral is kaolinite. |
| North Carolina kaolin | Grain size, coarse. The clay is mainly crystalline kaolinite. It contains, as an impurity, a very small amount of mica. |
| Washed Georgia kaolin | Grain size, very fine. The clay contains much rutile and mica as impurities. |
| Florida plastic kaolin | Grain size, very fine. The clay contains a small amount of quartz and rutile as impurities. |
| English china clay | Grain size, coarse. The clay contains much mica and quartz as impurities. |
| Delaware kaolin | Grain size, extremely fine. The clay contains, as impurities, large grains of quartz, mica, rutile, and iron minerals. |
| Coarse fraction of Georgia kaolin | Grain size, very coarse. The clay contains quartz, mica, and rutile as impurities. |

The melting points of the various clays have been determined, and the results in terms of pyrometric cone equivalents and approximate degrees centigrade are given in Table 2.

## TABLE 2. MELTING POINTS

| Clay | Pyrometric cone equivalents | Degrees centigrade (approximate) |
|---|---|---|
| Pike County kaolin | 35 | 1775 |
| North Carolina kaolin | 34 plus | 1760 |
| Washed Georgia kaolin | 34 | 1755 |
| Florida plastic kaolin | 32 | 1735 |
| English china clay | 34 | 1755 |
| Delaware kaolin | 32 | 1735 |
| Coarse fraction of Georgia kaolin | 34 | 1755 |

A chemical analysis was made of the Pike County kaolin sample. This indicates it to consist almost entirely of the mineral kaolinite ($2H_2O.Al_2O_3.2SiO_2$). The chief impurity is a small amount of iron oxide. The analysis is shown in Table 3.

TABLE 3. CHEMICAL ANALYSIS OF PIKE COUNTY KAOLIN

| | Per cent |
|---|---|
| Silica, $SiO_2$ | 44.04 |
| Alumina, $Al_2O_3$ | 39.25 |
| Iron oxide, $Fe_2O_3$ | 0.68 |
| Lime, CaO | 0.26 |
| Magnesia, MgO | 0.21 |
| Soda, $Na_2O$ | 0.10 |
| Potash, $K_2O$ | 0.03 |
| Ignition loss, $H_2O$ | 15.30 |
| | 99.87 |

The drying and firing behavior of the sample of the Pike County kaolin is summarized in Tables 4 and 5. These tests, conducted according to the standards recommended by the American Ceramic Society[2], were made in the student laboratories of the Ceramic Department, School of Mines and Metallurgy, Rolla, Missouri.

[2]American Ceramic Society Journal, September, 1928.

TABLE 4. DRYING BEHAVIOR OF PIKE COUNTY KAOLIN

| | |
|---|---|
| Working properties | The clay molds with extreme difficulty, and is fairly non-plastic |
| Water of plasticity | 55.5 per cent |
| Drying shrinkage, volume (dry basis) | 23.84 per cent |
| Drying shrinkage, linear (dry basis) | 8.16 per cent |
| Drying behavior | The clay dries easily and develops no cracks |

TABLE 5. FIRING BEHAVIOR OF PIKE COUNTY KAOLIN

| Temperature of firing | Pyrometric cone equivalent | Per cent absorption | Apparent specific gravity | Per cent volume change |
|---|---|---|---|---|
| 1159° C. | 2 | 16.9 | 2.68 | 36.2 |
| 1172 | 3 | 14.7 | 2.71 | 39.1 |
| 1175 | 4 | 13.1 | 2.62 | 38.5 |
| 1183 | 5 | 12.8 | 2.55 | 37.4 |
| 1190 | 6 | 9.83 | 2.43 | 42.5 |
| 1215 | 7 | 9.11 | 2.59 | 43.3 |
| 1223 | 8 | 8.13 | 2.71 | 44.4 |
| 1250 | 9 | 8.94 | 2.67 | 44.4 |
| 1260 | 10 | 9.04 | 2.70 | 44.8 |
| 1285 | 11 | 9.72 | 2.69 | 45.1 |
| 1310 | 12 | 8.37 | 2.69 | 45.7 |
| 1356 | 13 | 8.48 | 2.69 | 45.8 |
| 1389 | 14 | 7.76 | 2.70 | 45.8 |
| 1414 | 15 | 8.92 | 2.73 | 45.5 |

The tested sample of the Pike County kaolin during firing changed in color from a good white at the lowest temperatures to a light-gray at the higher temperatures. The firing behavior tests indicate that this clay has properties which make it suitable for whiteware or for refractory ware.

## CERAMIC INVESTIGATION

The Pike County kaolin was tested in bodies, or mixtures with other ceramic materials, to determine its desirability for utilization in whiteware manufacture. As a basis for comparison, a series of similar bodies were prepared in which were substituted other kaolins commonly used in the whiteware industry. The clays used for comparison are listed below:

1. Pike County kaolin
2. North Carolina kaolin
3. Coarse fraction of Georgia kaolin
4. Washed Georgia kaolin
5. Florida plastic kaolin
6. English china clay
7. Delaware kaolin

The bodies of mixes were selected to cover a wide range in the ceramic field. These included the sanitary ware bodies in which the casting process is used and the electrical insulating porcelain bodies and the vitreous china bodies in which the plastic method of forming is used. These bodies are designated according to letter, and each mixture numbered according to the kaolin used in the body formula.

TABLE 6. BODY COMPOSITIONS

| | Body A Electrical porcelain (per cent) | Body B Cast sanitary ware (per cent) | Body C Vitreous china body (per cent) |
|---|---|---|---|
| Feldspar | 30 | 30 | 15 |
| Kentucky No. 4 ball clay | 40 | 10 | 7½ |
| Tennessee No. 5 ball clay | ... | 10 | 7½ |
| Kaolin | 10 | 24 | 30 |
| Flint | 20 | 26 | 40 |

The electrical porcelain body and the vitreous china body were each prepared by placing the weighed ingredients in a ball mill with sufficient water to make a thin slip. Each mixture was allowed to grind for two hours, after which it was emptied into a plaster of Paris absorption bowl lined with a wet cloth, and allowed to stand until just enough water had been removed to form a workable mass. The usual bars and translucency wedges were formed from this material.

The sanitary ware body was prepared by the process known as the direct ball mill method. In this procedure the entire amount of the ball clays, and all the sodium silicate and water, are put into a ball mill and ground for fifteen minutes. This completely deflocculates the ball clays and puts them into suspension. The ball clay slip then is passed through a 100-mesh sieve to remove the coarse organic material, and placed back in the clean ball mill along with all the sodium carbonate and kaolin. The mill is rotated for half an hour in order to break down and deflocculate the kaolin. When this has taken place the feldspar is added and the mixture ground for half an hour, after which the flint is added. After grinding one hour longer, the slip is ready to be poured into bar molds of plaster of Paris.

The above methods were followed in forming the 21 samples of the several bodies. These samples were air dried for at least 72 hours, then dried at 100° C. for 24 hours, after which some of the bars from each body were tested for dry strength, and all were measured for dry shrinkage. The unbroken bars were baked in an oil-fired kiln at various temperatures for 18 hours, and allowed to cool. Each of these bars was tested for firing shrinkage, fired strength, absorption, fired color, and warpage, and the special pieces tested for translucency. All the tests were conducted according to the standards of the American Ceramic Society. Each of the tests is summarized below:

1. Dry shrinkage: each bar when molded was marked by a parallel cut of a knife 5 inches apart. When the bar was perfectly dry, the distance between marks was measured again. Then

$$\text{Dry shrinkage} = \frac{\text{molded length - dry length}}{\text{dry length}}$$

2. Fired shrinkage: after the bar was fired and cooled, the distance between marks was measured and recorded. Then

$$\text{Fired shrinkage} = \frac{\text{dry length - fired length}}{\text{fired length}}$$

3. Dry strength: after all the bars were dried at 110° C., half of them were broken in a Riehl testing machine. The weight required to break the bars and the breadth and depth of the bar at the fracture were recorded. The modulus of rupture was calculated according to the formula:

$$\text{Modulus of rupture} = \frac{3 \text{ x load x span}}{2 \text{ x breadth x depth}^2}$$

4. Fired strength: after the bars were fired, they were broken and calculated similarly to the dry strength.

5. Absorption: half of the broken bars were weighed, put into a pan of hot water, and allowed to boil

for two hours. The pan was removed from the fire and 24 hours later the bars taken from the water, wiped with a damp cloth and weighed again. The percentage of absorption was calculated according to the formula:

$$\text{Absorption} = \frac{\text{wet weight - dry weight}}{\text{dry weight}}$$

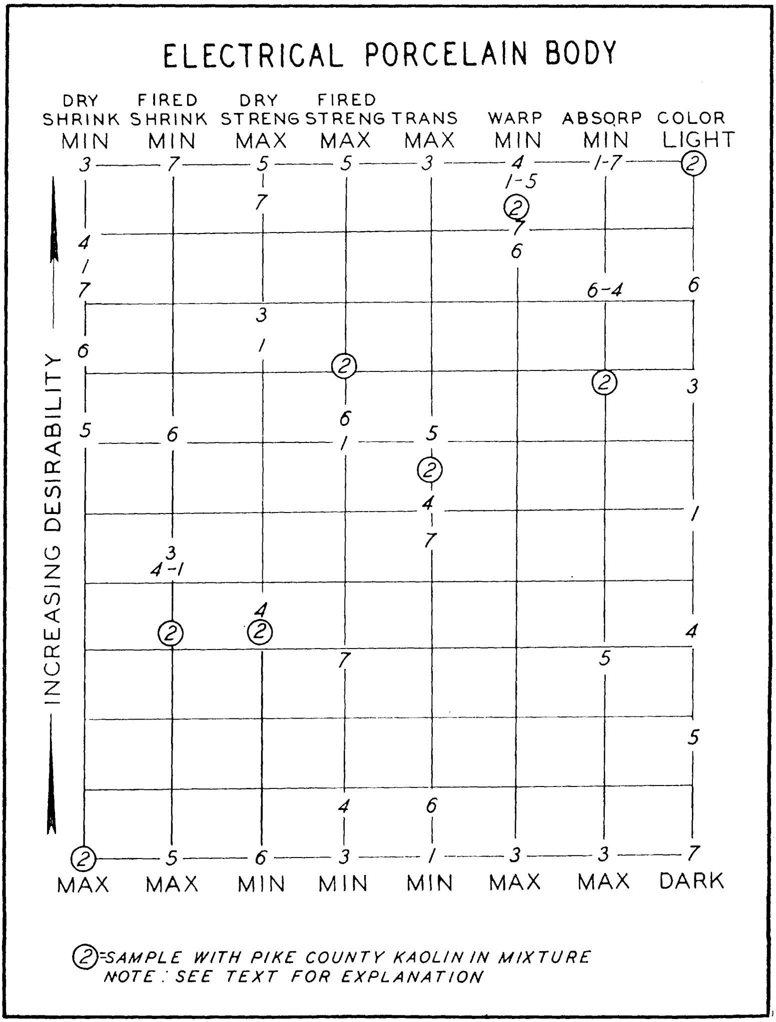



**Figure 1. Electrical porcelain body**

6. Warpage: the bars especially prepared for this test were 6 inches by 1 inch by ½ inch thick in the dry state. During firing these bars were supported on refractory bars with a span of five inches. In this way the bars tended to bow under their own weight depending on the amount and type of glass formed during firing. The bars were measured for any warpage before firing and again afterwards at exactly the same spot. Warpage was calculated as follows:

   Warpage = fired deformation - dry deformation

7. Translucency: special pieces 1 inch by 3 inches by ¼ inch thick tapering to zero thickness were formed from each body and fired. The pieces were then held in front of a slit in back of which was a 100-watt light bulb. The thickness of the pieces where the observable transmitted light just faded out was taken as a measure of the translucency.

8. Fired color: a sample from each body was freshly broken and the fracture held up to a steady white light. The pieces were arranged so that No. 1 was the whitest body and No. 7 the darkest body.

The data resulting from the various tests made are tabulated in Tables 7, 8, and 9.

## TABLE 7. ELECTRICAL PORCELAIN BODY

| No. | Clay | $H_2O$ of plasticity | Dry shrinkage | Fired shrinkage | Dry strength | Fired strength | Translucency | Warpage | Absorption | Color |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | North Carolina kaolin | 29.9 | 4.71 | 9.28 | 383 | 6350 | .517 | .125 | .04 | 4 |
| 2 | Pike County kaolin | 29.9 | 6.57 | 9.48 | 346 | 6610 | .650 | .156 | .13 | 1 |
| 3 | Coarse Georgia kaolin | 28.2 | 4.39 | 9.25 | 387 | 5350 | .755 | .938 | .32 | 3 |
| 4 | Washed Georgia kaolin | 25.0 | 4.64 | 9.28 | 349 | 5470 | .640 | .109 | .09 | 5 |
| 5 | Florida plastic kaolin | 28.2 | 5.24 | 10.14 | 406 | 7120 | .663 | .125 | .24 | 6 |
| 6 | English china clay | 26.6 | 4.98 | 8.93 | 317 | 6460 | .533 | .206 | .09 | 2 |
| 7 | Delaware kaolin | 28.2 | 4.78 | 8.16 | 401 | 5830 | .626 | .188 | .04 | 7 |

## TABLE 8. CAST SANITARY WARE

| No. | Clay | Dry shrinkage | Fired shrinkage | Dry strength | Fired strength | Translucency | Warpage | Absorption | Color |
|---|---|---|---|---|---|---|---|---|---|
| 1 | North Carolina kaolin | 3.60 | 9.96 | 281 | 4684 | 1.063 | .938 | 1.29 | 3 |
| 2 | Pike County kaolin | 7.17 | 10.75 | 205 | 3659 | .920 | .219 | 1.95 | 2 |
| 3 | Coarse Georgia kaolin | 4.10 | 12.46 | 140 | 5111 | .593 | .125 | .54 | 4 |
| 4 | Washed Georgia kaolin | 2.35 | 10.22 | 243 | 4223 | .726 | .156 | 1.61 | 5 |
| 5 | Florida plastic kaolin | 5.00 | 10.12 | 205 | 3460 | .770 | .219 | 4.56 | 1 |
| 6 | English china clay | 2.76 | 11.08 | 199 | 6220 | .690 | .031 | .98 | 6 |
| 7 | Delaware kaolin | 3.40 | 9.58 | 140 | 4000 | .616 | .422 | 2.17 | 7 |

## TABLE 9. VITREOUS CHINA BODY

| No. | Clay | $H_2O$ of plasticity | Dry shrinkage | Fired shrinkage | Dry strength | Fired strength | Translucency | Warpage | Absorption | Color |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | North Carolina kaolin | 28.2 | 3.65 | 4.04 | 157 | 2650 | .546 | .172 | 10.60 | 4 |
| 2 | Pike County kaolin | 29.9 | 6.14 | 5.96 | 200 | 3190 | .636 | .078 | 7.97 | 1 |
| 3 | Coarse Georgia kaolin | 29.0 | 3.79 | 8.05 | 112 | 3260 | .490 | .172 | 13.80 | 6 |
| 4 | Washed Georgia kaolin | 25.0 | 4.07 | 9.25 | 121 | 5190 | .436 | .141 | 2.13 | 3 |
| 5 | Florida plastic kaolin | 31.6 | 5.53 | 8.60 | 203 | 4000 | .493 | .141 | 3.95 | 2 |
| 6 | English china clay | 28.2 | 4.15 | 9.64 | 130 | 4420 | .656 | .156 | 2.75 | 5 |
| 7 | Delaware kaolin | 28.2 | 4.54 | 7.36 | 127 | 3590 | .430 | .141 | 6.09 | 7 |

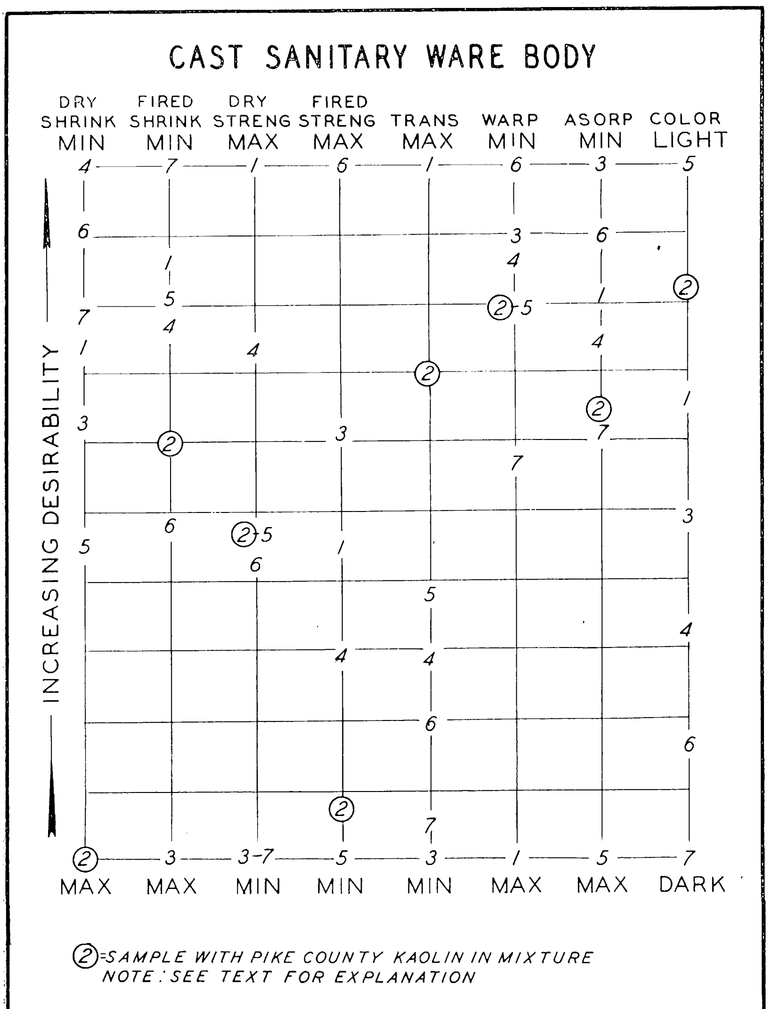



**Figure 2. Cast sanitary ware body**

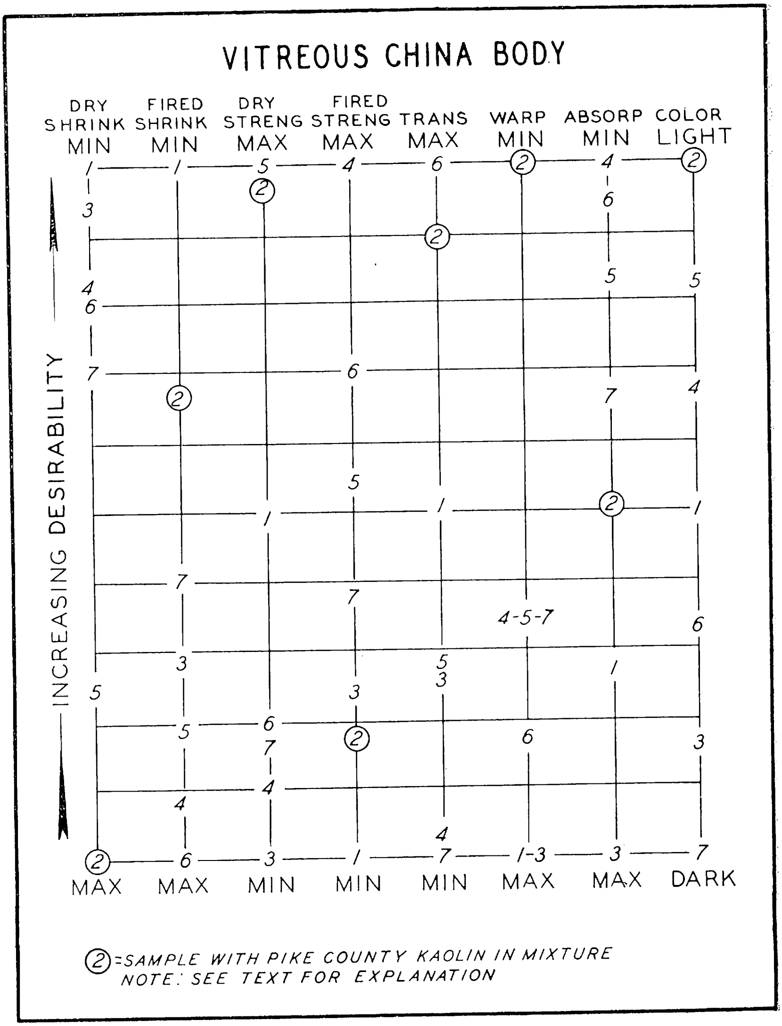



Figure 3. Vitreous china body

Figures 6, 7, and 8 summarize the relation of the various clays in each body. At the top of each graph are listed the clays having the most favorable quality in each test, while at the bottom are listed the most unfavorable clays in each case. Between these extremes the other clays are placed in their appropriate positions. It should be noted that in the ideal ceramic body drying shrinkage, firing shrinkage, warpage, and absorption should be at a minimum, and dry strength, fired strength, translucency, and light fired color at a maximum.

In general, it can be said that a body will not have all the required favorable qualities at maximum desirability, nor all the unfavorable qualities at a minimum. For example, a certain clay in a body may develop a great deal of glass which allows maximum translucency but also promotes maximum warpage. Therefore, in practice, the clay to be used would be one which would be a compromise between all the properties in which we are interested. In order to evaluate easily the various clays, the graphs are divided into unit blocks and according to its position each clay is arbitrarily graded from 1 to 10 for each property. Therefore, the clay having the lowest total grade is best for ceramic purposes for which the body is used, and that with the highest total, the worst. The relative desirability of the various clays, rated according to this system, is summarized for the three bodies in Tables 10, 11, and 12.

TABLE 10. RELATIVE DESIRABILITY OF VARIOUS CLAYS IN ELECTRICAL PORCELAIN

| No. | Clay | Dry shrinkage | Fired shrinkage | Dry strength | Fired strength | Translucency | Warpage | Absorption | Color | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | North Carolina kaolin | 2 | 6 | 3 | 5 | 10 | 1 | 1 | 6 | 34 |
| 2 | Pike County kaolin | 10 | 7 | 7 | 3 | 5 | 1 | 4 | 1 | 38 |
| 3 | Coarse Georgia kaolin | 1 | 6 | 3 | 10 | 1 | 10 | 10 | 10 | 45 |
| 4 | Washed Georgia kaolin | 2 | 6 | 7 | 10 | 5 | 1 | 2 | 7 | 40 |
| 5 | Florida plastic kaolin | 4 | 10 | 1 | 1 | 4 | 1 | 8 | 9 | 38 |
| 6 | English china clay | 3 | 4 | 10 | 4 | 10 | 2 | 2 | 2 | 37 |
| 7 | Delaware kaolin | 2 | 1 | 1 | 8 | 6 | 1 | 1 | 10 | 30 |

In electrical porcelain the translucency and color seldom are considered of importance, and may therefore be disregarded in evaluating a clay for such a body. If this is done, the relative desirability of the kaolins for use in electrical porcelain is as follows:

1. Delaware kaolin
2. North Carolina kaolin
3. English china clay
4. Florida plastic kaolin
5. Pike County kaolin
6. Washed Georgia kaolin
7. Coarse Georgia kaolin

## TABLE 11. RELATIVE DESIRABILITY OF VARIOUS CLAYS IN CAST SANITARY WARE

| No. | Clay | Dry shrinkage | Fired shrinkage | Dry strength | Fired strength | Translucency | Warpage | Absorption | Color | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | North Carolina kaolin | 3 | 2 | 1 | 6 | 1 | 10 | 2 | 4 | 29 |
| 2 | Pike County kaolin | 10 | 5 | 6 | 10 | 4 | 3 | 4 | 2 | 44 |
| 3 | Coarse Georgia kaolin | 4 | 10 | 10 | 4 | 10 | 2 | 1 | 6 | 47 |
| 4 | Washed Georgia kaolin | 1 | 3 | 3 | 8 | 8 | 2 | 3 | 7 | 35 |
| 5 | Florida plastic kaolin | 6 | 2 | 6 | 10 | 7 | 3 | 10 | 1 | 45 |
| 6 | English china clay | 1 | 6 | 6 | 1 | 9 | 1 | 2 | 9 | 35 |
| 7 | Delaware kaolin | 3 | 1 | 10 | 9 | 10 | 5 | 4 | 10 | 52 |

According to this rating, the relative desirability of the kaolins for use in cast sanitary ware is as follows:

1. North Carolina kaolin
2. Washed Georgia kaolin and English china clay
3. Pike County kaolin
4. Florida plastic kaolin
5. Coarse Georgia kaolin
6. Delaware kaolin

## TABLE 12. RELATIVE DESIRABILITY OF VARIOUS CLAYS IN VITREOUS CHINA

| No. | Clay | Dry shrinkage | Fired shrinkage | Dry strength | Fired strength | Translucency | Warpage | Absorption | Color | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | North Carolina kaolin | 1 | 1 | 6 | 10 | 5 | 10 | 8 | 6 | 47 |
| 2 | Pike County kaolin | 10 | 4 | 1 | 9 | 2 | 1 | 5 | 1 | 33 |
| 3 | Coarse Georgia kaolin | 1 | 8 | 10 | 8 | 8 | 10 | 10 | 9 | 64 |
| 4 | Washed Georgia kaolin | 2 | 10 | 9 | 1 | 10 | 7 | 1 | 4 | 44 |
| 5 | Florida plastic kaolin | 7 | 9 | 1 | 5 | 8 | 7 | 2 | 2 | 41 |
| 6 | English china clay | 3 | 10 | 9 | 4 | 1 | 9 | 1 | 7 | 44 |
| 7 | Delaware kaolin | 3 | 6 | 9 | 7 | 10 | 7 | 4 | 10 | 56 |

According to this rating the relative desirability of the kaolins for use in vitreous china ware is as follows:

1. Pike County kaolin
2. Florida plastic kaolin
3. Washed Georgia kaolin and English china clay
4. North Carolina kaolin
5. Delaware kaolin
6. Coarse Georgia kaolin

## CONCLUSIONS

The various tests and accumulated data indicate that the Pike County kaolin has some ceramic properties which are superior to the other clays used in this investigation. The results of this study are summarized below:

1. The Pike County kaolin is desirable for the manufacture of vitreous whiteware, in those cases in which color, minimum warpage, and considerable dry strength are the important factors.
2. In general, it can be said that for use in ceramic bodies the desirability of the Pike County kaolin increases as the bodies require greater amounts of kaolin. Thus, in a 10 per cent mixture (the electrical porcelain body), the Pike County clay ranks fifth; in a 24 per cent mixture (the cast sanitary ware body), it ranks fourth; and in a 30 per cent mixture (the vitreous china clay), it ranks first.
3. The Pike County kaolin has the highest dry shrinkage of all the materials tested. This is an undesirable feature for most ceramic purposes.
4. The Pike County kaolin and the Florida kaolin show marked similarities in many of the tests. This indicates that the Pike County kaolin can be substituted for Florida plastic kaolin in most ceramic bodies. In the ceramic industry Florida plastic kaolin is known as a very pure kaolin with some of the desirable properties of ball clays.