A DETERMINATION OF THE COLLOID CONTENT OF CERTAIN TENNESSEE CERAMIC CLAYS[1]

JOHN B. BOND, JR.,

AUSTIN PEAY NORMAL SCHOOL, CLARKSVILLE, TENNESSEE

Distribution of Clay in Tennessee

Practically every county in Tennessee has more or less clay suitable for the making of brick. The clays along the Tennessee and Cumberland Rivers are especially well adapted for the making of building brick. Large operations in this line are carried on in the outskirts of all the principal cities.

West Tennessee is abundantly supplied with clays and is rapidly becoming the center of a great clay industry. In fact, practically the entire surface of West Tennessee can be utilized in the making of common brick. Pottery, drain tile, brick, and other clay products are made in a number of counties, and the industry is still in its infancy.[2]

Aside from the surface clays used all over the State for the manufacture of brick and tile, Tennessee possesses large quantities of high-grade china clays and pottery clays. Ball clays, equal in every respect to the English ball clays, and rapidly replacing their use, occur in a belt over West Tennessee, crossing Henry, Carrol, Gibson, Madison, Hardeman, and Fayette Counties. The clay occurs in lenses from 18 to 20 feet thick down to a feather edge and over areas from one to two acres up to ten to twelve acres or more. Sagger, wad, and fire clays are abundant in the same areas.[3]

Method of Analysis

Two main types of clays were collected for examination in this study: common clays suitable for the making of common building brick and of tile, and fine Tennessee bond and refractory clays.

The Bouyoucos Soil Colloid Hydrometer Method was used to measure the colloid content of the samples of clay.[4] This method and its modification is outlined briefly. Ten grams of air dried clay, previously pulverized and sifted through a one-half millimeter seive, were placed in a 500 c.c. nickle-plated cup such as is used for mixing malted milk, in which a series of wire baffles had been soldered to prevent the contents from assuming a rotatory motion. The cup was then filled to within two inches of the top with distilled water, 3 c.c. of normal KOH were added and the contents of the cup dispersed by a fan-

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[1]Especial thanks are due Dr. H. A. Webb of George Peabody College for Teachers for helpful advice and criticisms. Read before the Tennessee Academy of Science, November 29, 1929.

[2]*Tennessee.* Published by Department of Agriculture, State of Tennessee, page 43.

[3]*The Resources of Tennessee.* Tennessee Geological Survey, Volume 9, No. 2, April, 1919, page 92.

[4]Bouyoucos, G. J. *A Rapid Method for the Mechanical Analysis of Soils.* Soil Science, Volume 25, No. 6, page 365, June, 1927.

shaped stirrer three-fourth inch in diameter driven by an electric motor, such as is ordinarily used for mixing drinks. The motor was capable of making 14,000 revolutions per minute without a load. This stirring apparatus was allowed to run for nine minutes. The contents of the cup were then poured into a special cylinder which was seventeen inches high and two and one-half inches in diameter, with a capacity of about 1200 c.c. The hydrometer was placed in the clay suspension in the cylinder and water was added to bring up to the mark 1205 c.c. This cylinder held 1000 c.c. of water plus the amount of water displaced by the hydrometer and the clay. The hydrometer used was one of special make calibrated to read the number of grams of clay in suspension per liter of water when the temperature was 67 degrees Fahrenheit. It was designed by Professor George J. Bouyoucos of the University of Wisconsin. The soil was thoroughly mixed in the cylinder by placing the palm of the hand over the top and shaking for one minute. The cylinder and its contents were placed on a level table and the time noted. At the end of fifteen minutes the hydrometer was read and the temperature of the clay suspension taken. From the reading of the hydrometer and the temperature correction the per cent of colloid was calculated. According to Bouyoucos, colloids are those particles which stay in suspension at the end of 15 minutes.

It was found by experiment that ten grams of clay was the most suitable quantity of sample to take for the determination, for with the larger samples the clay suspension was so thick that it was obvious that the per cent of error would be great. With a ten-gram sample it is also much easier to calculate the per cent of colloid: the hydrometer is read in grams of colloid in solution or in per cent of colloid plus or minus temperature correction.

In order to determine the percentage of colloidal material in the clay, the number of grams per liter, as indicated by the reading on the hydrometer, is divided by the weight of the soil taken and multiplied by 100 and then corrected for temperature. This reading is calibrated to 67 degrees Fahrenheit. A change of one degree makes a difference of .35 per cent of colloids. For temperatures above 67 degrees the corresponding amount is added, and for temperature below 67 degrees the corresponding amount is subtracted.

When the proper amount of alkali is added to a clay-water suspension the viscosity of the liquid is decreased and the particles remain in suspension for a greater length of time. This is called the deflocculated condition. The addition of alkali to a clay suspension increases the negative charge on the particles until a certain point is reached where further additions decrease the charge. The point of maximum charge occurs in the region of maximum deflocculation.[5]

For every clay-water-electrolyte there is a pH value at which the rate of settling is a minimum. Hall[6] found that the point of maximum

[5]Wilson, Hewitt, *Ceramics*.

[6]Hall, F. P. *The Effect of Hydrogen Ion Concentrations upon Clay Suspensions.* Journal of American Ceramic Society, 6: (9), 999, 1923.

deflocculation varied for different clays between pH 11.0 and 12.0. Three cubic centimeters of normal KOH were used because it was found by experiment that this quantity of alkali gave the maximum deflocculation of the ten grams of clay. However, the Tennessee Number 11 Ball Clay was deflocculated to the greatest extent with 1 c.c. of normal KOH, and was flocculated by amounts over 2 c.c. of normal KOH.

Tabulation of Data

Two colloid determinations for each sample were run. The following table ranks the clays in order of per cent colloid:

TABLE 1

Table ranking clays in order of their colloid content as determined by the hydrometer method. The temperature in all cases was seventy-nine degrees Fahrenheit.

NAME OF CLAY	PERCENT OF COLLOIDS	
	SAMPLE 1	SAMPLE 2
Tenn. No. 9 Ball Clay, Paris, Tenn.	94.2	94.2
Tenn. No. 10 Ball Clay, Paris, Tenn.	89.2	94.2
Tenn. Special Ivory Ball, Paris, Tenn.	84.2	84.2
Ky. No. 12 Black Ball, near Paris, Tenn.	84.2	84.2
Ky. Special Ball, near Paris, Tenn.	84.2	84.2
Ky. No. 4 Plastic Fire, near Paris, Tenn.	84.2	84.2
Ky. No. 5 Ball, near Paris, Tenn.	84.2	84.2
Tenn. No. 5 Ball Clay, Paris, Tenn.	84.2	84.2
Tenn. No. 7 Ball Clay, Paris, Tenn.	79.2	79.2
Tenn. No. 1 S. G. P. Ball Clay, Paris, Tenn.	79.2	84.2
Ky. Old Mine No. 4 Ball, near Paris, Tenn.	79.2	79.2
Tenn. No. 11 Ball Clay, near Paris, Tenn.	59.2	64.2
Hardison Blue Clay, Nashville, Tenn.	59.2	59.2
Clay from Peabody, 4′ deep, Nashville, Tenn.	59.2	59.2
Russell Pottery Clay, Paris, Tenn.	54.2	59.2
Bush Chattanooga Clay, Chattanooga, Tenn.	54.2	54.2
White Clay from Highland Rim	54.2	54.2
Clay Poor in Phosphate, Spring Hill, Tenn.	49.2	44.2
Clay from Peabody, 2′ deep, Nashville, Tenn.	49.2	49.2
Bush Common Brick Clay, Nashville, Tenn.	44.2	44.2
Tennessee-Alabama line Clay	44.2	44.2
Bush Alabama Dirt	39.2	44.2
Hardison Red Clay, Nashville, Tenn.	39.2	44.2
Hardison Sand Loam, Nashville, Tenn.	39.2	39.2
Hardison Red Dirt, Nashville, Tenn.	39.2	39.2
Clay Rich in Phosphate, Spring Hill, Tenn.	39.2	39.2
Clay Good in Phosphate, Spring Hill, Tenn.	39.2	39.2
Clay from Peabody Surface, Nashville, Tenn.	34.2	34.2
Bush Nashville Dirt, Nashville, Tenn.	24.2	29.2
Road Clay near Spring Hill, Tenn.	14.2	19.2

Interpretation of Data

All of the finer ball clays were found to be very high in colloid content. These clays have been used with excellent results and for a great many years in the following lines: sanitary ware, high tension and standard electrical porcelain, wall tile, spark plugs, abrasives, grinding wheels, semi-porcelain tableware, hotel china, and in glazes.

The clays from Bush and Hardison Brick Yards and the Russell Pottery have a range from 24 to 59 per cent colloids. The Hardison blue clay used for brick making is classed as a "fat" clay with large shrinkage. This clay has a colloid content of 59 per cent, while the Hardison red clay which makes a more uniform brick with less shrinkage and crackage, has a colloid content of 39 per cent. Bush's clay for common and press brick makes a very uniform product and has a colloid content of 44 per cent. This seems to indicate that the most desirable clays for the making of common, matt, and press brick are those which have a colloid content range from 30 to about 60 per cent. Most all of the common clays tested came within this range.