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Firing behavior of Missouri plastic fire clay

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FIRING BEHAVIOR OF MISSOURI PLASTIC FIRE CLAY

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THESIS

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INTRODUCTION

There are two districts in Missouri in which plastic fire clay occurs. The oldest and least significant of these deposits is the "Cheltenham", in the St. Louis area. The most prominent area in which plastic fire clay occurs is generally termed the "east central" district. Included in this district are Calloway, Montgomery, Audrain, Warren, Boone, Monroe, Pike and Lincoln Counties.[1] The clay as tested in this report occurs in Boone County, near Columbia.

A plastic fire clay does not have as high a P.C.E. (pyrometric cone equivalent) as the ordinary flint and semi-flint clays, but its high plasticity warrants its use in the manufacture of refractories as an aid in the forming process. Plastic fire clays are also used in the production of second-grade refractory products. The chief difference between plastic fire clay and semi-flint clay is that the plastic fire clay contains more impurities and has a higher alkali content.

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1. "Influence of Missouri Fire Clay on the Refractories Industry." A.P. Green Fire Brick Co.

It is essential that, before any clay can be placed upon the commercial market, the various physical properties as described in this report must be determined. This is true because of several reasons. Fundamentally, from a monetary standpoint it is necessary to know if a prospective clay will have desirable properties so that it can be mined, formed, dried, fired and sold at a profit. It is by these tests that a clay may be determined of commercial importance or otherwise useless.

Practically all clays and clay bodies show a decrease in size on drying. This is attributed to the loss of mechanical water, which acts as a maitrix between the particles, holding them apart, and also the pressure developed on the surface of the object during the process of drying.

It is necessary to know the drying shrinkage and the burning shrinkage of a clay in order that due allowance be made in the making up of green shapes, so that the size and shape of the finished piece will be correct.

In general then, the firing behavior of a clay must be pre-determined, so that the entire processing of the materials involved will be as efficient and economical as possible.

DESCRIPTION OF CLAY

The plastic fire clay as tested occurs in the Pennsylvanian formation in the vicinity of Columbia, Mo. The clay is gray in color, has an argillaceous odor when wetted and has a soft feel. The clay does not, however; blunge without comparitively fine preliminary grinding. The clay as sampled for this report occurs only a few inches below ground-level.

FORMING

The plastic fire clay sample (approximately 30 lbs.) was passed successively through a jaw crusher, set of rolls and a Braun Pulverizer. This equipment was of laboratory size. Upon grinding, the clay was passed through a 20 mesh seive. Water was then added until a plastic condition was reached suitable for wedging on a plaster board. Upon wedging, the clay was formed into 1" x 1" x 6" bars and 1" x 1" x 1-7/8" bars in hand-operated brass laboratory molds.

DRYING

1-7/8" specimens after determining the plastic volume of the bars were dried for 48 hours at 110°C. in a steam-operated dryer.

P.C.E.

Test cones were made of the clay in accordance with American Ceramic Society specifications and were placed in a circular plaque along with standard cones and thus fired in an electric "gran-annular" P.C.E. furnace.

PLASTIC VOLUME

The plastic volume was determined immediately upon forming in a Seger volumeter. Kerosene of specific gravity of about 0.8 was used as the measuring fluid. After the plastic volume was determined, the surfaces of the test pieces were dried lightly with a soft cloth to remove the film of kerosene, and allowed to dry at room temperature until air dry. They were then dried at a temperature between 64 and 76 deg. C. to approximately constant weight. After this treatment the specimens were dried as described under "DRYING".

WATER OF PLASTICITY

The water of plasticity is the water necessary to bring the clay to a good working consistency. It is expressed as a percentage by weight of the dry clay. The water of plasticity varies between wide limits, being high for plastic, fine-grained clays and low for sandy and non-plastic clays.

POROSITY

Porosity is the percent by volume of the open pores of the fired piece. Porosity equals saturated weight of the fired piece minus the weight of the fired piece divided by the volume of the fired test piece. The units for this method of determination must be measured in the C.G.S. system.

ABSORPTION

Absorption is the percent by weight of the water absorbed by the open pores of the body. Absorption equals saturated weight of the fired piece minus the dry weight of the fired piece divided by the dry weight of the test piece x 100.

APPARENT SPECIFIC GRAVITY

The apparent specific gravity is found by the weight of the dry fired piece divided by the volume of the dry fired piece excluding the open pores.

FIRED VOLUME

The fired volume is determined directly by placing the saturated piece in the volumeter and determining the cubic centimeters of liquid displaced.

HARDNESS

The hardness is noted as being either harder or softer than steel, due to the difficulty in making such a test.

COLOR

The color is determined by visual observation.

FIRING

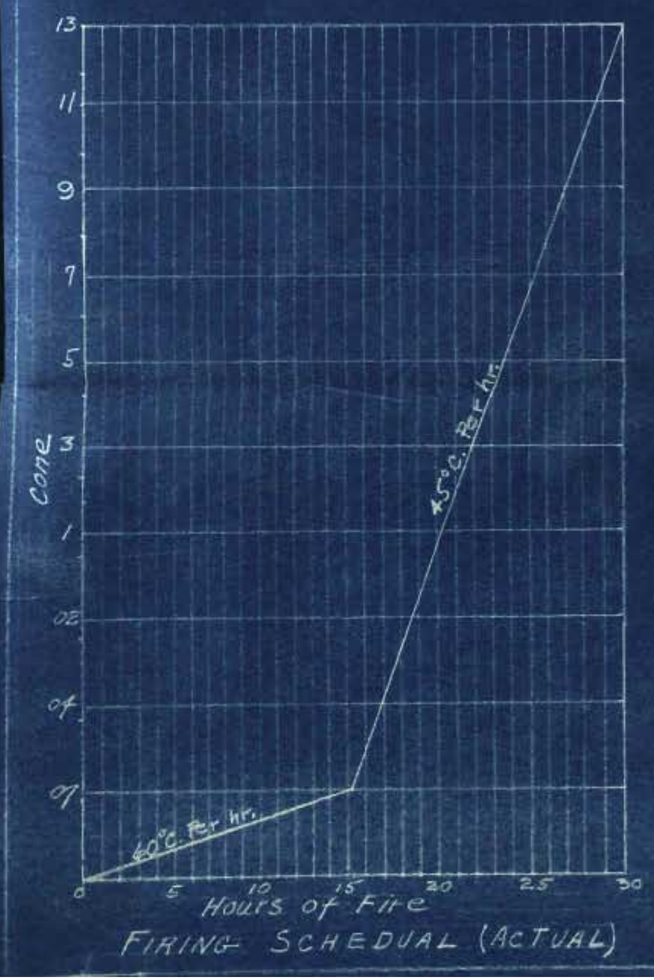
The firing was carried out in an oil fired down-draft laboratory kiln. The schedule is included in graphic form on attached page. The cone numbers represent the actual draws as performed in the laboratory.

SAMPLE FROM HOLE "D". FIRECLAY DEPOSIT ON L.L. RIDGE PROPERTY — NEAR COLUMBIA, MO. By W.E. CROCKETT, '41.

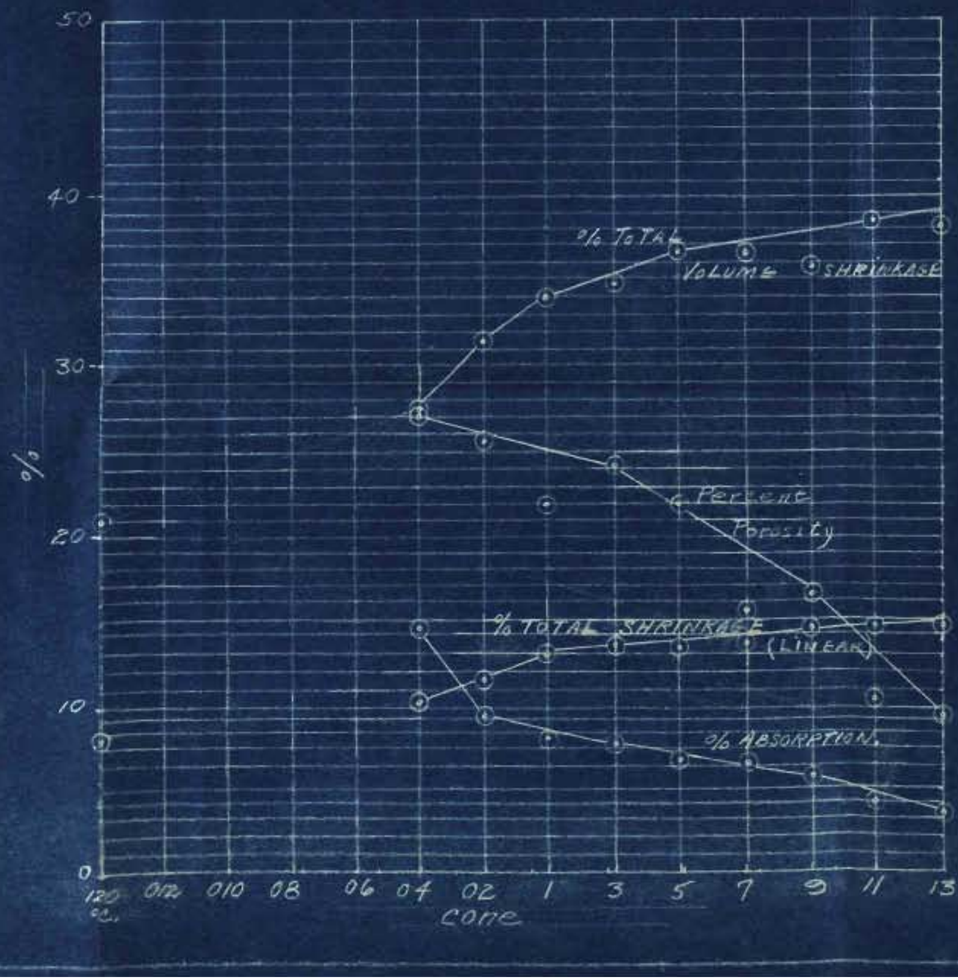
P.C.E. = CONE 29 – 30 WATER OF PLASTICITY = 21% GREEN LENGTHS = 5.0" & 1-7/8" (Volume determinations)

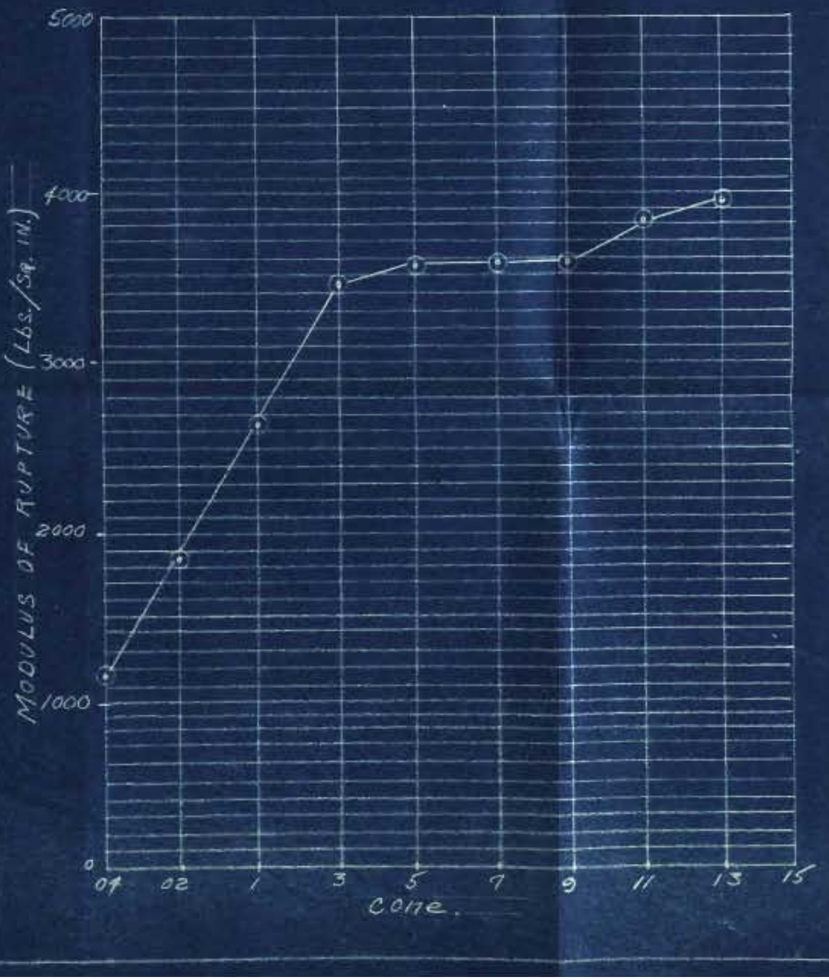
CONE	BAR NO.	PLASTIC WT.	DRY WT.	DRY LENGTH	FIRED LENGTH	FIRED WT. 5"	FIRED WT. 1-7/8"	SAT. FIRED WT. 5"	SAT. FIRED WT. 1-7/8"	PLASTIC VOLUME	DRY VOLUME	FIRED VOLUME	DRY LINEAR SHRINKAGE	DRY VOLUME SHRINKAGE	FIRED VOLUME SHRINKAGE	FIRED LINEAR SHRINKAGE	TOTAL VOLUME SHRINKAGE	TOTAL LINEAR SHRINKAGE	% POROSITY	APPARENT S.G.	HARDNESS	% ABSORPTION	MODULUS OF RUPTURE P	L	b	d	M	COLOR
04	1	179.0 gm.	144.5	4.63	4.52	129.6	40.0	145.0	45.7	28.4 cc.	22.2	20.0	7.4 %	21.8%	7.8%	2.2 %	29.6 %	9.6%	28.5 %	2.8	<6	17.5 %	115	5"	.88"	.90	1210	GRAY
	2	184.7	145.6	4.61	4.46	131.4	39.8	148.0	45.7	28.3	22.1	20.8	7.8	21.9	4.8	3.0	26.7	10.6	25.8	2.6	"	11.2	125	"	.76	.91	1140	"
02	3	174.0	138.3	4.62	4.44	124.3	42.0	139.0	48.0	30.8	23.1	20.9	7.6	23.0	10.0	3.6	32.0	11.2	23.0	2.7	<6	9.3	165	"	.75	.90	1990	LIGHT GRAY
	4	175.0	142.0	4.63	4.40	127.0	41.0	139.5	46.5	29.3	23.0	20.7	7.4	21.5	7.9	4.6	29.4	12.0	26.5	2.7	"	9.1	150	"	.71	.92	1770	LIGHT GRAY
1	5	183.5	146.0	4.63	4.36	130.0	40.6	141.0	45.2	29.2	22.4	19.1	7.4	23.2	11.3	5.4	34.5	12.8	24.1	2.8	<6	7.8	200	"	.81	.96	2530	" "
	6	175.5	139.0	4.62	4.34	124.2	41.0	135.0	45.0	29.7	23.7	19.8	7.6	20.2	13.2	5.6	33.4	13.2	20.2	2.6	"	8.0	215	"	.92	.86	2660	" "
3	7	179.0	141.8	4.65	4.31	125.8	41.1	136.0	46.5	29.6	23.7	19.2	7.0	19.9	15.7	6.8	35.6	13.8	22.9	2.8	6	7.5	205	"	.80	.87	2570	" "
	8	187.0	150.0	4.63	4.35	134.0	39.0	144.0	43.5	28.0	22.5	18.5	7.4	19.7	14.3	5.6	34.0	13.0	23.3	2.8	6	6.9	245	"	.75	.84	3360	" "
5	9	176.0	140.0	4.62	4.36	125.3	41.2	134.0	45.5	30.0	24.0	19.2	7.6	20.0	16.0	5.2	36.0	12.8	22.4	2.7	76	6.6	255	"	.72	.85	3680	" "
	10	183.0	144.9	4.62	4.33	130.8	40.2	138.0	44.0	29.4	22.8	18.5	7.6	22.0	15.2	5.8	37.2	13.4	20.5	2.7	"	5.9	250	"	.75	.85	3490	" "
7	11	177.0	140.0	4.60	4.32	129.8	42.0	138.5	44.6	29.9	23.5	18.5	8.0	21.4	16.8	5.6	38.2	13.6	14.0	2.6	"	6.3	275	"	.78	.86	3580	GRAY
	12	177.2	141.0	4.62	4.32	126.7	44.0	131.0	47.4	31.1	25.2	20.4	7.6	19.0	15.5	5.0	34.5	13.6	16.6	2.6	"	6.1	270	"	.74	.89	3600	"
9	13	185.0	148.5	4.62	4.29	133.0	43.7	141.0	46.8	30.4	24.0	19.2	7.6	21.1	15.7	6.6	36.8	14.2	16.1	2.8	"	5.7	280	"	.78	.84	3550	"
	14	162.8	129.0	4.62	4.28	115.2	48.2	121.0	57.7	32.2	26.5	21.5	7.6	20.8	12.6	6.8	33.4	14.4	16.3	2.7	"	5.6	290	"	.74	.90	3620	"
11	15	170.5	134.0	4.62	4.26	120.5	43.0	126.0	44.6	30.6	25.1	18.7	7.2	18.0	21.0	7.2	39.0	14.8	8.6	2.5	"	4.4	285	"	.76	.85	3920	"
	16	169.3	134.0	4.62	4.27	120.5	41.7	125.0	44.0	29.8	23.6	18.4	7.6	20.8	17.6	7.0	38.4	14.6	12.5	2.6	"	3.6	295	"	.78	.86	3700	"
13	17	164.0	130.0	4.62	4.26	116.2	40.8	120.5	42.6	28.5	22.7	17.5	7.6	20.2	18.1	7.2	38.3	14.8	10.3	2.6	"	3.6	350	4"	.74	.86	3920	BUFF
	18	169.7	134.2	4.62	4.25	120.0	41.6	124.0	43.0	28.8	23.0	17.9	7.6	20.1	17.7	7.4	37.8	15.0	7.8	2.5	"	3.2	360	4"	.77	.84	3980	"

GRAPHIC DATA BELOW IS BASED ON AVERAGES OF ABOVE DATA.



FIRING SCHEDUAL (ACTUAL)





DISCUSSION OF RESULTS

The tabulated data would seem to indicate the following uses for the clay as tested:

1. As a 2nd grade fire clay or as a plastic fire clay.
2. As a stoneware clay.
3. As a modeling clay.

The clay has a good green strength, is free from coarse sand and other coarse foreign matter and is low in iron content. It has a P.C.E. of cone 29-30.

The clay dries without excessive warping or checking and does not require slow or careful drying. If the clay should be used in the manufacture of pottery (stoneware) probably cone 5-7 would be the most suitable bisque range if the clay were used alone with no other ingredients present.

The clay may be hand-formed, but will not cast suitably in a plaster mold with no other ingredients present. Undoubtedly, the clay can be made to cast nicely when present up to 50% in a mixed body.

In the practical firing range of the clay, the color is light gray and is approximately as hard as steel. The porosity ranges from approximately 15 to 20% throughout this range, thus in a stoneware manufacture, the clay would require a glaze. The clay takes a slip glaze nicely.

The clay seems to be free from coarse particles of any kind which would produce spots and blemishes on the surface, providing further sampling does not produce different results.

The iron content is apparently low, as it should be in the manufacture of refractory products or stoneware. This would be especially beneficial if the ware were to be salt-glazed.

The temperature at which the clay should be fired is easily attained with common fuel, thus the economic feasibility of producing the clay product in any locality is helped.

Before any too conclusive statements can be made concerning the exact possibilities of this clay, it will be necessary to do some extensive prospecting, so as to definitely locate the extent of the deposit (at the present time it is known to outcrop along a creek for at least one mile) and at the same time determine the general quality of the clay. There should also be a series of tests run on the clay, such as actual ware production under conditions as are found in industry.

The apparent possibilities of this specific fire clay deposit are somewhat limited at the present time due to lack of transportation facilities; the nearest rail shipping point being approximately 5 miles away.

The clay has been used to a limited extent as a modeling clay and has the possibility of this application in the art field, however; the economic importance of such an application would be very limited.