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of the copper or by Traube's theory which is backed up by almost convincing evidence[3].

Stannous chloride will reduce sulphuric acid with formation of hydrogen sulphide and free sulphur, an analogous reaction in which the assumption of "nascent" hydrogen is inadmissible.

[3] Moritz Traube, *loc. cit.* and *Ber.*, 18, 1877, etc.

CLAYS OF THE INDIANOLA BRICK, TILE AND POTTERY WORKS

L. A. YOUTZ, INDIANOLA.

Analyses of several clays from a brickyard at Indianola have recently been made by me to go into a report of the Geological Survey of Warren county. Though it has been said that a knowledge of the constituents of a clay, determined by a purely chemical analysis, is of very little value to a practical brick-maker, yet in comparing the analyses of these clays and those from other vicinities, it seems that points of great value to the manufacturer are made plain, and points that can be derived from no other source. So I wish to give a few ideas which came to me as I made the comparison, as points, of local interest at least, were, it seems to me, clearly brought out.

In order to get an intelligent idea of the value of this clay for brick and tile it may be helpful to give a short outline of some of the qualities of clay for the various kinds of brick. The quality and character of brick depends, of course, primarily upon the kinds of earth used; the mechanical mixing, drying and burning being important items, however.

The varieties of clay most frequently used for common bricks are three. The so-called blue clays, hydrated aluminum silicates, combined with small quantities of iron, calcium, magnesium and alkalis; sandy clays or loams, and marls which contain a large proportion of lime and magnesium. In addition to these are the clays for special kinds of brick, as fire-brick, pottery, terra cotta, etc. Hydrated silicate of aluminum is infusible even at the most intense furnace heat, but if these be mixed with alkalis, or alkali earths, it becomes fusible, and in about the proportion of the admixture. So that clays containing more than about 3 per cent of lime can not be made into good brick from this fact, and that the calcium carbonate being reduced to calcium oxide by heat will slack by moisture and the brick then crumble. However, by burning at a higher temperature than is usual the injurious effect of lime can be greatly overcome unless it is in so great quantity as to lower the fusing point too much. The amount of combined water in a clay is a very important item in determining its adaptability for good brick. In a pure hydrated silicate of aluminum so much water will be given off by burning that the brick in going through the sweating process become too soft and run together, or else crack so as to be made much inferior. So all pure clays for brick must be mixed with sand, powdered quartz, powdered brick, gangue, or some such material, in order to alleviate this difficulty. In loams a certain per cent. of lime or similar material needs to be added to act as a flux, as too much sandy material makes the brick brittle. Marls in this country have been, it appears, but little used for brick making, as the lime is supposed to be detrimental. Yet in Europe a very fine malm is made from marls having as high as 40 per cent or more of calcium carbonate. They simply heat the brick probably 200 degrees higher than the ordinary brick. This gives the brick a white color instead of red, the iron and calcium being united with the aluminum as a ferric-aluminum-calcic silicate.

Of the Indianola brick clays, analyses of two samples will be sufficient for our purpose of comparison. The brick are made from a certain small deposit of blue clay, taken probably twenty feet below the surface, mixed with a much larger proportion of a darker colored clay immediately above this blue layer.

The lower strata gave the following analysis from the air dried samples:

$Si\,O_2$	66.779
$Al_2\,O_3$	19.525
$Fe_2\,O_3$	.72
Ca O	trace
Loss dried at 100°	8.08
Loss by ignition	5.48
Total	100.584

The sample above this as follows:

$Si\ O_2$	67.85
$Al_2\ O_3+Fe_2\ O_3$	20 45
$Ca\ O$	1.19
$Mn\ O$	trace
$K_2\ O$	trace
Loss dried at 100°	3.47
Loss by ignition	7.12
Total	100.08

It will be seen that in each there is a large per cent. of silica and alumina. The upper containing more free silica, consequently gave a higher per cent of silica and alumina, but contained a considerably smaller per cent. of hygroscopic moisture, The higher loss by ignition in the upper stratum being due doubtless, to a larger amount of organic matter near the surface. Lime was present in the upper stratum in appreciable quantity, and iron in small quantity in each. A trace of manganese oxide in the upper stratum.

From Crossley's "Table of Analyses of Clays" for common brick we take three average samples, which are as follows:

Common brick clay:

$Si\ O_2$	49.44
$Al_2\ O_3$	34.26
$Fe_2\ O_3$	7.74
$Ca\ O$	1.48
$Mg\ O$	5.14
Water and loss	1.94
Total	100.00

Sandy clay:

$Si\ O_2$	66.68
$Al_2\ O_3$	26.08
$Fe_2\ O_3$	1.26
$Mg\ O$	trace
$Ca\ O$	.84
Water and loss	5.14
Total	100.00

Marl.—London "Malms."

$Si\ O_2+Al_2\ O_3$	43.00
$Fe_2\ O_3$	3.00
$Ca\ O$	46.50
$Mg\ O$	3.50
Water	4.00
Total	100.00

Comparing the Indianola clay with these, with the first it is at variance especially in silica, alumina, and oxide of iron. With the second it corresponds very well except in Al_2O_3 and in having more water. But we could not call it a sandy clay. The upper layer contains a little sand, but the lower practically none. To the third there is no comparison.

It seems then as these clays represent the three common classes of brick, that this clay at Indianola must represent a kind which though it may make, as it has proven itself to do, good common building brick, yet it may be adapted to other kinds of brick.

The Stourbridge, England, clays, from which the world-famed fire brick are made, yield, by averaging the analyses of four different clays, the following proportion of materials:

No. 1.

SiO_2	64.95
Al_2O_3	22.92
Fe_2O_3	1.90
$CaO+MgO$	.64
K_2O+Na_2O	.37
H_2O loss	9.60
Total	100.38

Woodbridge fire clay bed, New Jersey, also famous for its quality of refractory clays, as follows:

No. 2.

SiO_2 combined	40.50	
SiO_2 free (quartz sand)	6.40	46.90
Al_2O_3	35.90	35.90
TiO_2	1.30	1.30
K_2O+Na_2O	.44	
Fe_2O_3	1.10	1 54
H_2O combined	12.80	
H_2O hygroscopic	1.50	14.30
Total	99.94	99.94

From Trenton, New Jersey:

No. 3.

SiO_2 combined	17.50	
SiO_2 free (quartz sand)	56.80	74.30
Al_2O_3	18.11	18.11
K_2O+Na_2O+CaO	1.07	1.07
$Fe_2O_3+H_2O$	6.99	6.99
Total	100.47	100.47

These three samples of fire brick clays are selected from a list of about 100 analyses of clays taken from various parts of the United States and Europe, and, I think, represent a fair average as to composition. From these it may be seen that in general a large amount of Al_2O_3 and SiO_2, with small amounts of alkali, or alkali earths, or iron oxide, is characteristic of these highly refractible clays. Further, it seems that a large per cent. of Al_2O_3 over SiO_2 increases the infusibility. However, there seem to be two varieties of fire clay, varying considerably in composition, which make equally good fire brick. One is where the silica is nearly all combined with a percentage of about 40 to 50 per cent, and a large amount of aluminum oxide—probably 25 to 35 per cent.—and water making up the greater amount of the remaining 100 per cent. This clay, of course, as the per cent. of the alumina over the silica and these two over other metallic oxides increases, finally runs into kaolin. The other kind is one where the combined silica is small and the alumina less than in the first case, the combined silica probably not having a much higher percentage than the alumina, the remaining part being made up almost entirely of free silica (quartz sand) and water. No. 2 above illustrates the first and No. 3 the second class.

By comparing the Indianola clays with these it will be seen that the average is essentially the same as No. 1. This being an average of several samples of each of the two classes referred to above, *i. e.*, No. 2 and No. 3. But in the Indianola clays there is but small amount of free silica. This being the case, and from the fact that it is so free from magnesia, lime, potash, and iron oxide, it would seem that this clay would be well adapted to be used as the clay basis of fire brick, and then the necessary amount of free silica (either powdered quartz, glass, or silicious brick dust) be added. By a very careful comparison of all the clays the analyses of which I have, and the qualities of brick made from these, theoretically it seems to me by this means very superior fire brick could be made. The fusibility of bricks made by this method with this clay as far as I know has not been determined. Yet it seems it would be an experiment worth trying, and one which we may attempt at a later date.

I am informed that the pottery made at this plant is not made from the clay at Indianola, but is made from clay taken just above the upper vein of coal at Carlisle, Iowa. I have not analyzed this clay and cannot at present make a comparison.