The Clays of Five Mile Creek.

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READ AT LOGAN MEETING.

Five Mile Creek finds its source among the hills of West Central Starr township, Hocking county. It flows north and empties into the Hocking river, one and one-half miles below Logan.

The geological structure of this limited field presents no very strange features. A series of engineers' levels show some little irregularities in the dip. The rock falls less than ten feet from near the mouth of Five Mile to Union Furnace, a distance of four miles. From Union Furnace to the south it rises, until at Summit Mine it has risen thirty-five feet. The distance from Union Furnace to Summit Mine is about one and one half miles. South of the Summit the rock again falls toward Starr. Across the field east and west there is no reverse dip, but the levels show three benches or steps. The following section will show the geological range of the field:

Upper Freeport Limestone—		
6.	Flint Clay, } Interval.....	23
	Coal,	
	Interval.....	0—18
Lower Freeport Limestone—		
5.	Flint Clay, } Interval.....	27—30
	Middle Kittanning Coal,	
	Interval.....	30
4.	Lower Kittanning Coal and Clay,	
	Interval.....	60
3.	Tionesta Coal and Clay,	
	Interval.....	19
	Upper Mercer Horizon(black slate)	
	Interval.....	31
2.	Lower Mercer Lime, Coal and Clay,	
	Interval.....	15—20
	Sand Block Ore,	
	Interval (from O. G. S.)....	65—100
1.	Maxville Clay.	

There are six horizons of clay in this field, of more or less economic value, exclusive of valuable beds of red clays which cap the hills at and above the Freeport horizons. If we reverse the position of the clays placing the Maxville at the top of the list and the Freeport at the bottom we will have them in the order of their importance and value in this field. The Maxville

clay is a dark gray, blue gray, to light gray flint clay. It is often highly marked with organic impressions and stains. The fracture is irregular, sometimes conchoidal where best developed. The clay is usually without the so-called fire clay grain though not always. It disappears below drainage near the mouth of Five Mile. Thus far no attempt has been made to reach it either by shaft or test-well along this run.

It lies near enough the surface to warrant such exploration. It is mined on the Westenhaver place, southeast of Logan, and in several places northeast and north of Logan. The flinty character of the clay, the compactness of the seam, together with the absence of soft clay, makes the mining difficult and expensive. The clay is won by making a bearing-in above the clay and wedging up. The coal which sometimes overlies the clay serves for a bearing-in. Miners have been paid $1.00 per ton for mining. The royalty asked is 25 cents per ton. On board cars at Logan, the clay will cost $1.75 per ton.

The chemical composition indicates a high grade clay.

I have arranged in a table the analyses of several of the best flint clays for comparison:

	Logan—Maxville.	Kentucky—Maxville.	Vinton Co.—Maxville.	Sciotoville—Maxville.	Mineral Point.	Mt. Savage, Md., N. J. report.	Stourbridge, Eng., N. J. report.	Average of three clays which stood highest heat, N. J. report.
Silica	42.51	44.32	43.92	52.48	35.39	38.50	30.50	43.72
Alumina	37.56	40.42	37.64	34.39	31.84	30.08	22.52	36.30
Combined water.	13.03	13.86	13.24	11.00	11.68	7.00	8.30	13.30
Koolin base	93.10	98.60	94.80	.....	78.91	76.58	61.32	93.32
Quartz	3.99	.....	.57	*	17.13	16.90	33.65	2.43
Titanic acid	.....	.....	.....	.....	1.68	1.15	1.00	1.27
Inactive impur's.	.....	.....	.....	.....	18.81	18.05	34.65	3.70
Sesqui oxide iron	.78	.76	.92	1.28	.67	1.69	1.43	1.03
Lime	.40	.28	.15	} .89	.50	} 2.30	} .50	.08
Magnesia	.05	.....	.12		.19			.07
Potash	1.38	.44	.74	....	.59	....	....	.24
Total alk...	2.61	1.48	1.83	2.17	1.95	3.99	1.93	1.42
Moisture	1.16	.....	1.94	.....	.69	.90	2.10	1.67
Total	100.86	100.08	99.14	100.04	100.36	99.52	99.90	100.11

* Probably from $Si\ O_2$—not separated.

The clay belongs to the Kaolinitic variety, which admits of a wider use than the silicious clays.

The Logan clay, I believe, will make a high grade fire-brick, but the brick must be made, not thrown together. The clay should be thoroughly washed, a high percentage of *true* calcine thoroughly mixed with it, a small percentage of carefully selected bond clay should be used. By small percentage I mean, only sufficient to give a good bond at an intense heat, not at an ordinary heat. I believe brick should be burned at as high a temperature as they will be required to withstand in metallurgical operations.

By using crushed quartz with the clay and silicious bond clay, we may extend the use of the Logan clay to resist the action of more silicious slags.

The Lower Mercer horizon gives us the next most important clay. The seam is made up of three parts, as follows:

White clay	24″ to 48″
Black clay	12″ to 18″
White clay	12″ to 24″

The white and black clays of this seam are widely different. The white clay is a coarse grained sandy clay, containing more or less undecomposed material and runs high in alkali.

The black clay belongs to the Kaolinitic class of clays. It is low in impurities, both silicious and alkaline. When first mined it is quite hard with conchoidal fracture. The color is brown-black.

The following analyses show the composition of these clays:

	BLACK SEAM, PROF. LORD.	WHITE SEAM, PROF. LORD.	BANK RUN.
Silica	46.10	69.30	58.19
Alumina	35.60	20.70	27.64
Combined water	12.90	5.50	8.72
Sesqui oxide of iron	1.28	1.17	1.39
Lime	.74	.54	.51
Magnesia	.64	.47	.64
Potash	1.62	3.13	2.70
Moisture	1.97	.46	1.15

A comparison of the analysis of the black seam with those of other bond clays is very favorable to this clay. While its physical characteristics are unexcelled for bond clay purposes, the grain is fine and close. Under treatment, the clay is highly plastic, insuring a strong primary bond with the use of a minimum amount of clay; while the final bond is obtained only after long continued, intense heat.

The white clay is not a high grade fire material. The high percentage of silica, much of it free or as undecomposed mineral, together with the excess of potash, are sufficient proof of its non-refractoriness. It has, however, very desirable qualities for a building brick. It burns to a uniform buff color. The secondary or final bond is perfect. It has one other redeeming quality which places it high in the scale of building material. The brick do not show any efflorescence, which make so many pressed brick buildings unsightly.

Without going into the subject of efflorescence on brick, let me give briefly the explanations of it which have been offered. Analysis has shown it to be sulphate of the alkalies with iron and traces of lime and magnesia which, being soluble, is brought to the surface of the brick by alternating rain and sunshine. One explanation is that the air in our smoky cities, ladened with oxidized sulphur fumes and moisture, act on the impurities in the mortar to form the sulphate. This sulphate is dissolved in a wet period, absorbed by the brick, and in a subsequent dry period brought to the surface of the brick by capilarity, and left there by evaporation.

In another explanation the alkalies in the clay, acted upon by the sulphurous anhydride from our soft coals used in burning the brick, forms the required product, which needs only the atmospheric agencies to complete and bring to the surface of the brick. The brick from the Lower Mercer clay are laid in mortar in a manufacturing city using soft coal, with none of the many devices to avoid the evil as first explained. They are burned in various kinds of kilns using soft coal high in sulphur. If we use Tionesta clay, a clay having one-third less alkali than the Lower Mercer, and burn it at the same time, in the same kiln with the Lower Mercer, the first change from wet to dry after removing the brick from the kiln, brings the white or green efflorescence to the surface of the Tionesta brick while the Lower Mercer brick remains unchanged.

The explanations do not explain. In the above case the difference must be in the clay and not in the burning or laying.

At the Upper Mercer horizon is a plastic clay which has never been worked along Five Mile. Immediately overlying the Upper Mercer, at Union Furnace, is a rock of some importance. It is a fire sandstone which has done good service in the old Logan and Union furnaces. It was claimed for this rock that it had less tendency to crack and spall off. An analysis of the rock explains why. It has 23 per cent. of kaolin base. The total active impurities are less than 2 per cent. The rock is massive, and from twenty to twenty-five feet thick. When first quarried it dresses or crushes readily, but after long exposure to the atmosphere it hardens. The rock in its natural state is now doing service in the hearth of Franklin Furnace at Columbus. In the form of

brick it is being used in cupola furnaces, to which work it seems well adapted.

We next come to the Tionesta clay which has given me several puzzles. The seam is made up of two parts—in the bottom two to four feet of black clay, and about the same amount of white clay on top. The clay weathers like a flint clay, it crumbles to pieces instead of forming a mud. It is silicious in composition. The kaolin base is 64.5 per cent.; the total silica, 61.7 per cent.; potash, 2.10 per cent; the free silica, nearly 30 per cent., is in a fine state of division. The temptation to use this clay is great. It stands high pressure without cracking, and important item in dry or semi-dry press work. It takes a fine finish, has an unusually strong primary bond, and burns to a deep buff color. In all these respects it is far superior to the Lower Mercer clay, and besides, the clay is more refractory than the Lower Mercer. Why then do we not use it? The brick under the action of heat has a tendency to spall off, even when the heat is raised very gradually.

This spalling off is due, I think, to the silica, the fineness of grain, and the density of the brick combined.

The deep buff color, the sharp edges, and the finish would have made a very desirable building material. But this is the clay which showed such unusual efflorescence. I sought for an explanation which would explain this case. I find in the clay little nodules of sulphide of iron, many of them not larger than a pin head. With a clay containing sulphide of iron and alkalies, exposed to an oxidizing flame, and subsequent to atmospheric agencies, we would not be greatly surprised to find sulphate of the alkalies brought out on the face of the brick. There is a very broad field for scientific investigation in this subject, which has scarcely been touched. The color of the efflorescence is white, and various shades of yellow and green. The variation in color may be due to an excess of one or other of the impurities.

In burning brick there is a successive bonding, or uniting of the impurities, with the clay and sand. Probably the potash combines first, possibly the lime second, the magnesia third, and the iron last. Whatever the order, in a soft brick containing soluble sulphates of the alkalies, all these alkalies will be found in the efflorescence. In a medium hard brick a part or all of the alkali, which bonds with the clay first, will be absent from the coating or efflorescence. Thus the composition of the efflorescence would vary with the degree of hardness of the brick, and the color would vary more or less with the variation in the composition. In a vitrified brick we would expect no efflorescence, and in fact we get none, even with the Tionesta clay.

The occurrence of sulphide of iron in fire-clays is not uncommon. We were compelled to reject some flint clay from two places in Vinton county, and also some clay from Kentucky on this account. They belong to the Maxville horizon. Very recently we

have come to recognize the superiority of the black portion of the seam. Unfortunately I have no analysis of the separate seams.

With difficulty we have succeeded in bonding a mixture of fire-sand and Lower Mercer clay in a common clamp kiln. Using the same amount of black Tionesta clay with the fire-sand, we have not succeeded in getting a satisfactory bond at the highest heat obtainable in an Endaly kiln especially constructed for high heats.

Our next clay lies under the Lower Kittanning coal. The seam at Union Furnace is about four feet. It has a uniform light drab color, is quite free from grit, and extremely plastic. Its plasticity and whiteness have gained for it the name of "whitewash." It gives a strong primary bond, burns to light buff color, bonds readily and vitrifies without difficulty. Its use in the manufacture of fire-brick will be limited. It is well adapted for paving brick, for building material, and for pottery.

Care must be taken in the manufacture of any product from this clay on account of its shrinkage, which is extreme.

Two other clays are found in the section. They are both flint clays of a light buff or drab color. The lower one is the most constant. It is by no means confined to Five Mile.

Wherever I have had an opportunity of examining the land I have found it from Carbon Hill to Minerton.

An analysis of the clay from Union Furnace shows but 1.64 per cent. impurities, not including, of course, the Free Silica. A similar clay from Kittanning, Ohio, which I think is the same horizon, shows 2.03 per cent. A sample from Carbon Hill had 2.66 per cent.

The clay belongs to the Silicious variety. Of four samples taken from Carbon Hill, Swackhammer farm, Union Furnace and Kittanning, the highest percentage of silica was 63.03 ; the lowest 58.84. We expected great results from this clay, but the results have not been realized. The clay, with us, has proved to be an out-crop of clay with coarse sandstone back of it.

On the out-crop we found fine grained, dense clay three to four feet thick; behind it was good clay with more or less sandy, open-grained clay mixed with; next came sandy, coarse-grained clay with some good clay bedded in it, and finally came the sand-rock. Our experiments with the out-crop have led us to regret its fickleness.

Above these clays, capping the hills, about the head-waters of Five Mile, are valuable beds of red clays.

This clay takes a velvet finish and burns to a rich, live red color.

Beyond a few experiments which have been very satisfactory, no attempt has been made to use it.

DISCUSSION OF MR. LOVEJOY'S PAPER.

This was very interesting, being participated in by Messrs. Willard, Morris, Price, Bancroft, Haseltine, Lovejoy, McClintock and Dr. Jas. Little, dwelling on the clays, the inexhaustible supply and their adaptability to various uses.

Brick pavements were discussed, red brick, fire brick and paving blocks, each kind being extensively laid in Columbus during the year.