cently it has expanded its facilities and is doing a very active business in making high grade glazed tile, using the same boulder clay for the tile body.

The following tests show the clay to be buff burning with a high lime content, which is partly counteracted by the magnesia, giving a burning range of six cones:

Burning Test

Sample No. 46. Field Sheet No. 45. SW¼ Section 25, T. 7 N., R. 7 W.
Plasticity .323 gm. water per gm. clay.
Average linear drying shrinkage 11.2 per cent.
Average tensile strength about 135 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	950	.391	2.9 %	Soft bruned	Salmon
08	990	.384	2.9	Soft burned	Salmon cream
06	1,030	.366	2.9	Soft burned	Cream
04	1,070	.296	2.5	Soft burned	Cream
02	1,110	.239	8.1	Hard burned	Dark cream
1	1,150	.043	14.0	Vitrified	Light brown
3	1,190	.022	14.1	Vitrified	Light gray brown
5	1,230	.012	15.2	Vitrified	Light olive
8	1,290	....	....	Melted	.....

Pottery clay. Easily molded.
Burned by H. W. Jackman.

Burning Test

Sample No. 47. Field Sheet No. 45.
Michigan Porcelain Tile Works, SW¼ Section 25, T. 7 N., R. 7 W.
Plasticity .309 gm. water per gm. clay.
Average linear drying shrinkage 10.9 per cent.
Average tensile strength about 115 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	950	.378	2.3 %	Soft burned	Pink
08	990	.391	1.3	Soft burned	Cream white
06	1,030	.400	3.0	Soft burned	Cream white
04	1,070	.382	3.6	Soft burned	Cream white
02	1,110	.325	5.9	Hard burned	Cream
1	1,150	.086	14.1	Hard burned	Light brown
3	1,190	.023	15.8	Vitrified	Light brown
5	1,230	.012	17.1	Vitrified	Light olive brown
8	1,290	....	....	Melted	

Easily molded; used as pottery clay.
Burned by H. W. Jackman.

Chemical Analysis

Red and blue clay of deposit in SW¼ Section 25, T. 7 N., R. 7 W.

	Red clay Sample No. 46		Blue clay Sample No. 47	
Loss on ignition	18.15%	18.73%	18.67%	18.70%
Silica (SiO_2)	39.66	42.38	43.20	42.79
Iron (Fe_2O_3)	2.78	4.82	4.38	4.60
Alumina (Al_2O_3)	21.95	15.74	16.24	15.98
Lime (CaO)	13.60	13.95	13.66	13.80
Magnesia (MgO)	1.54	3.50	3.10	3.30
Alkalies (Na_2O, K_2O)	2.61	....	....	2.11
	100.29%			101.28%

Analyzed by H. W. Jackman.

F. H. Van der Heyden formerly operated a brick yard at Ionia. Ries* visited this yard and reported the deposit as follows:

"Sand ..... 2 ft.
Fat clay ..... 6 ft.
Gravel ..... 2 ft.
Sandy clay ..... 12 ft.

A mixture of the upper and lower clay is commonly used as it gives the best results. A sample of this was tested (R. 181).

Its fineness is shown by the fact that when washed but few grains are retained on the 100 mesh sieve. "In tempering only 18 per cent of water was required, but this yielded a mass of high plasticity. This shrinks in the air 6 per cent and at cone 05 incipient fusion was just about reached, with a total shrinkage of 7 per cent, and the color creamy white. At cone 1 the total shrinkage was 12 per cent and the color buff. Vitrification took place at cone 2 and viscosity between cones 3 and 4.

The clay is used for making brick, and owing to its high plasticity tends to laminate when molded in a stiff mud machine. The yard is equipped with two different brick machines, viz. a Wallace stiff mud auger machine with a triple die and a Creager soft mud machine. The latter is used for the lower sandy clay, while the mixture of the upper and under clay is molded in the auger machine. The soft mud bricks, it is said, stand the weather much better. The Creager machine has the clay prepared for it in a six foot pug-mill and a pair of rolls.

The yard is also equipped with a hand power repress and the product includes some tile."

*Mich. Geol. Survey VIII, Pt. I, p. 52 (1900).

For purposes of comparison chemical analyses of the brick clays sample 22 and the pottery clay, sample 23, by A. N. Clark are here given.

Analysis No.	22	23
Silica	44.15%	40.15%
Alumina	10.00	11.25
Ferric Oxide	4.08	4.88
Lime carbonate	24.68	21.43
Magnesium carbonate	1.50	8.93
Alkalies	1.55	2.06
Organic matter	1.95	2.05
Water by difference	12.13	9.25

IOSCO COUNTY

Iosco County is largely covered by the Old Au Sable River Delta and is generally sandy. Just west of Tawas City running north for about 10 miles and south for a greater distance there is a strip of morainic and lake clays containing some pebbles that may be suitable for common red brick. From Tawas City west for about six or eight miles there is a wide strip of lake clay with morainic clay on the north side. This lake clay runs generally less stony toward the southwest where it may be suitable for a brown colored face brick. The clay is generally red, about 60 feet deep, and covered in places with two or three feet of sand. Sample 136 is from the eastern part of this strip in the southwest corner of Section 21, T. 22 N., R. 7 E. Sample 137 is from the western part and is excellent material for brick and tile.

Burning Test

Sample No. 137. Field Sheet No. 146.
Section 24 (s.), T. 22 N., R. 6 E.
Plasticity .270 gm. water per gm. clay.
Average linear drying shrinkage 18.0 per cent.
Average tensile strength about 210 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.283	1.0 %	1.78	Soft burned.....	Light red
08	990	.279	1.5	1.82	Soft burned.....	Light red
06	1,030	.187	4.0	1.94	Hard burned....	Red
04	1,070	.120	5.8	2.04	Hard burned....	Red
02	1,110	.028	7.4	2.18	Vitrified.....	Dark brown
1	1,150	.024	2.7	1.88	Vitrified.....	Chocolate
3	1,190	....	...	....	Viscous	

Reddish brown clay. Easily molded. Vitrified bricks swelled slightly and cracked. Suitable for brick and tile.

Burned by H. W. Jackman.

ISABELLA COUNTY

Just northeast of Mt. Pleasant there is an old delta of the Chippewa River which marks the western limit of the glacial lakes in the Saginaw basin. Northeast of Mt. Pleasant there is a large area of lake clay that is an extension of the adjoining area in the northwestern part of Midland County. It has the same general qualities. East of Mt. Pleasant the clay is covered with sand.

About 1900 DePotty made brick from a deposit of boulder clay three miles south of Clare, near Russell, in section 12, T. 16 N., R. 4 W. Some good brick and some poor brick were made. Sample No. 83 was taken from the side of a cut on State Highway M-14 about four and one-half miles south of Clare in sections 26 and 27, T. 16 N., R. 4 W. This sample is representative of the red boulder clay in this district which is found in the plains and drumlins mixed with gravel. It is from six to fifteen feet or more in depth.

Burning Test

Sample No. 83. Field Sheet No. 87.
Section 26-27, T. 16 N., R. 4 W.
Plasticity .241 gm. water per gm. clay.
Average linear drying shrinkage 10.1 per cent.
Average tensile strength about 129 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.334	−0.2 %	1.70	Soft burned.....	Pink
08	990	.348	−0.2	1.71	Soft burned.....	Pink
06	1,030	.344	−0.4	1.71	Soft burned.....	Pink
04	1,070	.334	0.7	1.74	Soft burned.....	Light tan
02	1,110	.292	0.7	1.85	Soft burned.....	Tan
1	1,150	.236	4.3	1.96	Hard burned....	Tan
3	1,190	.123	6.7	2.13	Hard burned....	Light olive
5	1,230	.032	7.4	2.16	Vitrified.....	Olive
7	1,270	.016	6.0	2.05	Vitrified.....	Olive
9	1,310	....	...	....	Melted	.....

Lime pebbles. Molded fairly easily but somewhat grainy. Suitable for common brick.

Burned by H. W. Jackman.

About 1880 soft mud brick was made from red burning boulder clay just south of Mount Pleasant. This brick was used in the older buildings of the town and seems to have been a fairly good product. Similar clay containing some lime pebbles and sand extends south through Shepherd to St. Louis, Gratiot County.

Thompson and Gere formerly operated brick yards, using the lake clay about one to two miles northeast of Mount Pleasant along the Chippewa River. These plants are dismantled and torn down.

Wademan owns a plant about one and one-half mile northeast of Mount Pleasant in Section 2, T. 14 N., R. 4 W. The plant is located just east of the Pere Marquette Railroad and is equipped with a Fate tile auger machine, a drying shed, and two 20 foot round down draft kilns. The clay runs about three to 12 feet deep and is covered by three feet of sand and gravel. The same kind of blue clay is found north of the Salt River up to Coleman and the Clare County line. Sample 82 was taken from the pit of Wademan's yard. The tests of this clay indicate that it may be used for cream brick and tile and possibly for some pottery purposes as it is very fine grained and molds readily to a very smooth product.

Burning Test

Sample No. 82. Field Sheet No. 86.
Section 2, T. 14 N., R. 4 W. Wademan's yard.
Plasticity 0.230 gm. water per gm. clay.
Average linear drying shrinkage 6.9 per cent.
Average tensile strength about 125 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.386	1.1%	1.60	Soft burned.....	Pink cream
08	990	.381	1.0	1.59	Soft burned.....	Cream
06	1,030	.400	0.6	1.59	Soft burned.....	Cream
04	1,070	.418	0.2	1.55	Soft burned.....	Cream white
02	1,110	.427	1.0	1.58	Soft burned.....	Cream white
1	1,150	.430	2.1	1.63	Soft burned.....	Cream white
3	1,190	.361	5.0	1.80	Hard burned.....	Buff
5	1,230	.127	13.0	2.34	Hard burned.....	Olive
7	1,270	.059	15.2	2.51	Vitrified.....	Olive
9	1,310	....	....	....	Melted	.....

Molded easily.
Burned by H. W. Jackman.

Chemical Analysis

Sample No. 82. Field Sheet No. 86.
Clay in Section 2, T. 14 N., R. 4 W.

			Average
Loss on Ignition	20.00%	19.75%	19.87%
Silica (SiO_2)	41.60	42.82	42.22
Iron (Fe_2O_3)	3.17	3.48	3.32
Alumina (Al_2O_3)	11.30	12.32	11.81
Lime (CaO)	14.89	15.01	14.95
Magnesia (MgO)	6.22	6.42	6.32
Alkalies ($Na_2 + K_2O$)			2.34
			100.83%

Analyzed by H. W. Jackman.

West of Mount Pleasant there is morainic boulder clay, generally containing lime pebbles and sand, and of little value. A few years ago the National Portland Cement Company was contemplating the erection of a cement plant on Coldwater Lake, section 30, T. 15 N., R. 5 W. The plan was to use marl from the lake and some of the adjacent boulder clay as raw material. The following tests of two samples of clay taken from the deposits proposed as raw material for cement indicates that the clay contains a ratio of about 4:1 silica to iron and alumina, which is near the maximum limit permissible in cement mixtures. This fact, taken in consideration with the generally unsatisfactory nature of boulder clays, should make it an object of suspicion as a raw material for cement. The burning tests indicate that it might be used for common brick or possibly tile, but a first class product could not be produced due to the lime pebbles and high lime content.

Chemical Analysis.

Sample No. 18.
15-20 acres at south end of Coldwater Lake.
SE¼ Sec. 30, T. 15 N., R. 5 W.

H_2O and organic matter.....	13.53%
Silica (SiO_2)	56.15
Total iron as Fe_2O_3.....	3.66
Alumina (Al_2O_3)	11.04
Lime (CaO)	11.43
Magnesia (MgO)	1.45
Alkalies ($K_2O - Na_2O$, Approx.).....	2.74

Analyzed by H. W. Jackman.

Burning Test

Sample No. 18. Section 30, T. 15 N., R. 5 W.

Cone No.	Cone Temp. °C.	Linear Shrinkage.	Porosity.	Hardness.	Color.
014	870	−1.2%	.381	Soft burned.....	Salomn
010	950	−0.5	.384	Soft burned.....	Salmon
08	990	−0.7	.383	Soft burned.....	Pale salmon
06	1,030	0.6	.381	Soft burned.....	Pale salmon
04	1,070	3.4	.340	Hard burned.....	Salmon gray
02	1,110	3.3	.296	(Incipient fusion) Hard burned.....	White spots (lime) Blue gray
1	1,150	4.5	.283	Hard burned.....	Blue gray
3	1,190	6.3	.220	Hard burned.....	Blue gray, showing green
5	1,230	...	....	Overburned, (viscous)	

Burning range 04 to 1.
Burned by H. W. Jackman.

Sample No. 19. Sec. 30, T. 15 N., R. 5. W.

North end of Coldwater Lake, 20 acres on Henry Cook and Mat Schaeffer's farms.

Chemical Analysis

H_2O and organic matter	10.92%
Silica (SiO_2)	57.65
Iron (Fe_2O_3)	4.20
Alumina (Al_2O_2)	12.54
Lime (CaO)	9.89
Magnesia (MgO)	2.54
Alkalies (K_2O — Na_2O)	2.26

Analyzed by H. W. Jackman.

Burning Test

Cone Temp. °C.	Cone No.	Linear Shrinkage.	Porosity.	Color.	Hardness.
870	014	1.0 %	.368	Salmon	Soft burned
950	010	0.5	.374	Salmon	Soft burned
990	08	0.4	.368	Pale salmon	Soft burned
1,030	06	1.1	.353	Salmon buff	Soft burned
1,070	04	7.1	.159	Violet gray. White spots (lime)	Hard burned
1,110	02	7.5	.148	Violet gray. White spots (lime)	Hard burned
1,150	1	8.3	.110	Violet gray. White spots (lime)	Hard burned
1,190	3	7.4	.615	Cream, showing green	Beginning to soften
1,230	5	...	....	.....	Viscous

Burning range 04 to 1.

Burned by H. W. Jackman.

JACKSON COUNTY

The Coal Measure shales are very near the surface in Jackson County, outcropping in the Grand River valley north of Jackson, where they are quarried by the American Vitrified Products Company and used for sewer pipe at the Jackson plant. The plant is in the north center part of Jackson just east of the Grand Trunk railroad on Porter Street, about 1,000 feet west of Cooper Street, SE¼ Section 27, T. 2 S., R. 1 W.

The shale is brought in on a narrow gage railroad. It is prepared by grinding in a dry pan and then tempering in a wet pan. These operations have a capacity of about 130 tons of shale a day. The tempered clay is then conveyed from the wet pan to the cylinders of the extrusion presses.

The plant is equipped with two steam presses for extruding sewer pipe and tile. The steam piston is 42 inches in diameter and operates under a steam pressure of 120 pounds per square inch. In this way 70 to 80 tons pressure are exerted on the die during extrusion. The combined capacity of the two presses is equivalent to 4½ miles of 6 inch tile per day, or about 1,500 carloads of finished ware per year. The extruded pipe issuing from the bottom of the press is cut off and carried on a truck to a suitable place on the drying floor. This is a slatted wood floor overlying steam pipes. The ware is burned in 19 round down draft kilns about 28 to 30 feet in diameter.

The present quarry is about four miles north of the plant in NE¼ section 11, T. 2 S., R. 1 W., just east of the Grand River. The old pits in section 15 and the southern part of section 11 have been exhausted. The low hills back from the river are capped by limestone. The Coal Measures containing the shale beds lie in the depressions between the hills. The shale is exposed along the banks of the river where it is quarried. The shale section contains one or more lenses of sandstone. Quarrying is done in a rather crude fashion, all of the picking and loading being done by hand.

Sample 74 was taken from the ground shale as discharged from the dry pan at the plant. The analysis and burning properties are very similar to the shale found at Grand Ledge. Quarry conditions are unfavorable in many ways and the Grand Ledge shale is considered more suitable material. Other deposits farther north and west of the present quarry may contain better material and should be investigated.

Burning Test

Sample No. 74. Field Sheet No. 74.

Section 10, T. 2 S., R. 1 W.

Plasticity .223 gm. water per gm. clay.

Average linear drying shrinkage 7.0 per cent.

Average tensile strength about 56 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
08	990	.285	−0.2 %	Soft burned	Salmon
06	1,030	.278	0.4	Soft burned	Salmon
04	1,070	.258	0.9	Soft burned	Salmon
02	1,110	.224	2.1	Hard burned	Salmon
1	1,150	.195	3.2	Hard burned	Red brown
3	1,190	.195	3.2	Hard burned	Red brown
5	1,230	.168	4.4	Hard burned	Red brown
7	1,270	.157	3.5	Hard burned	Red brown
9	1,310	.073	3.1	Vitrified	Gray

Molded easily,—good material for face brick and tile.

Burned by H. W. Jackman.

Chemical Analysis

Sample No. 74. Field Report Sheet No. 74.
NE¼ Section 11, T. 2 S., R. 1 W.

			Average
Loss on Ignition	6.67%	6.67%	6.67%
Silica (SiO_2)	66.51	65.25	65.88
Iron (Fe_2O_3)	3.80	4.01	3.90
Alumina (Al_2O_3)	22.50	21.79	21.90
Lime (CaO)	0.37	0.52	0.44
Magnesia (MgO)	0.46	0.86	0.66
Alkalies (Na_2O, K_2O)			1.77
			101.22%

Analysis by H. W. Jackman.

Many of the surface clays of Jackson County are derived in considerable part from the Coal Measure shales. Ries* gives the following report concerning the surface clays:

"There occurs a bed of potters' clay five miles west of Jackson, while at the Adler Brick Company, three and one-half miles west, a soft plastic surface clay is employed which burns red in parts and buff in others. The bricks are molded by the soft mud process and come into competition with the Detroit ones."

"The Bennett Tile Co. is located one and one-half miles east of town and utilizes a plastic clay, making drain tile and paving brick. They have a clay deposit seven miles from Jackson and a narrow gage road connects it with the works."

"The following is the composition of a clay from G. H. Wolcott's yard, Springport township, from Mineral Resources for 1896, p. 61. Analyzed by Mariner and Haskins:

Silica SiO_2	52.26%
Alumina Al_2O_3	22.95
Iron Oxide Fe_2O_3	8.15
Lime CaO	4.48
Magnesia MgO	1.32
Water, etc.	10.56
	99.72%

"This analysis indicates a more or less direct derivation from a coal measure shale."

*Mich. Geol. Survey VIII, Part I, p. 60 (1900).

The Zenith Portland Cement Co., organized July 17, 1900, with a capital of $700,000, planned to use marl and clay as found near Grass Lake. The plant site was located at the southeast end of Grass Lake.

A sample of clay from this location was analyzed by F. S. Kedzie* as follows:

Silica (SiO_2)	49.86%
Iron and Alumina ($Fe_2O_3 + Al_2O_3$)	21.22
Lime (CaO)	6.32
Magnesia (MgO)	2.75
Carbon Dioxide (CO_2)	5.44
Organic and water	7.14
Difference	7.21

About two and one-half miles southwest of Concord and the Michigan Central Railroad in SW¼ section 1, T. 4 S., R. 3 W., is an exposure of stony yellow clay in a cut in the road. The clay is about 20-25 feet thick under one to two feet of stony yellow sand, and is represented by sample 1027.

On the Wittenberg farm about one mile north of Cement City in SE¼ Section 32, T. 4 S., R. 1 E., there is a deposit of yellow and gray clay, about 15 feet thick, over 15 acres. The clay contains considerable sand and gravel. It was carefully drilled and analyzed by Mr. Kane of the Peninsular Portland Cement Company.

Silica	Iron and Alumina	Lime	Magnesia
68.60%	20.50%	2.10%	1.66%
62.88	23.00	1.60	1.77
68.60	21.70	1.80	1.48
69.86	18.30	1.00	.79
66.76	20.90	1.50	2.00
68.50	20.90	2.00	1.99
67.16	20.58	1.00	1.73

The above represents a set of holes covering about 15 acres which is the extent of the deposit. Unsuitable for cement.

Analysis of a composite of the entire deposit

	SiO_2	R_2O_3	CaO	MgO	Total
Insoluble part ..	64.88%	13.05%	.80%	1.15%	79.88%
Soluble part	1.56	6.29	.70	.50	9.05
Total of the two.	66.44	19.34	1.50	1.65	88.93

Wm. Kane, Penin. Ptld. Cement Co.,
Cement City.

Mich. Geol. Survey VIII, Part III, p. 288 (1900-3).

KALAMAZOO COUNTY

In the vicinity of Kalamazoo there are several small deposits of surface clay, that have been used for the manufacture of common brick. One of these deposits was formerly worked at Waits' yard on the western edge of the town.* This clay bank is a shallow deposit surrounded and underlain by sand. The clay burns red.

A larger deposit was formerly worked at Leonard's yard about six miles from the city on the South Haven branch of the M. C. railroad. Here the clay is about 14 feet thick, composed of an upper sandy clay and a lower fat clay. The two clays were mixed, tempered in ring pits, and molded in soft mud machines. The brick were dried on pallets and burned in scove kilns. A sample of these mixed clays was tested by Ries as follows:

Sample (Ries) 223.
Water of plasticity 23%.
Air shrinkage 6%.
Tensile strength 135-150 lbs. sq. in.
Soluble salts 0.7%.

Cone.	Total Shrinkage.	Burn.	Color.
04	14 %	Hard	Bright red
1	15 %	Hard	Brown red
2	17 %	Vitrified	.....
4	....	Viscous	.....

The clay is very plastic and seems to be good material for making face or pressed brick, and tile.

Kalamazoo is the site of the old Eagle Portland Cement Company. This plant was equipped with four vertical kilns, two of which were built in 1872, and produced a total of 300,000 barrels of cement before it was abandoned in 1882.

The Kalamazoo Sanitary Products Company makes washbowls and closets from imported clays.

Shields Brothers formerly operated a brick yard at Williams, about five miles beyond the Leonard yard on the South Haven branch of the Michigan Central Railroad. The yard is just south of the railroad in NE¼ section 30, T. 1 S., R. 12 W. The clay is about 30 inches thick over 10 acres. No brick has been produced since 1907. The reason given is that the brick could not be sold. The plant was still in good condition in 1922.

*H. Ries, Mich. Geol. Survey VIII, Pt. I, p. 56.

Sample 22 was taken from the pit and seems to be good material for face brick or tile.

Burning Test

Sample No. 22. Field Sheet No. 19.
Section 30, NE¼, T. 1 S., R. 12 W.
Plasticity .363 gm. water per gm. clay.
Average linear drying shrinkage 13.7 per cent.
Average tensile strength about 210 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.334	0.3 %	1.63	Soft burned	Salmon
08	990	.315	1.5	1.69	Soft burned	Salmon
06	1,030	.225	5.0	1.89	Semi-hard burned.	Light red
04	1,070	.066	10.1	2.24	Hard burned	Red
02	1,110	.004	10.4	2.28	Vitrified	Chocolate red
1	1,150	.038	8.3	2.07	Vitrified	Chocolate red
3	1,190	.127	−4.7	1.48	Viscous	Chocolate

Light brown clay, molded easily; suitable for face brick and tile. Burned by H. W. Jackman.

KENT COUNTY

Kent County has a considerable area, probably over 40 per cent, covered by boulder and moraine clays.

At Sparta The Clay Manufacturing Company works a ten acre deposit of reddish clay that seems to lie in the glacial outwash plain. The plant is located in the northeast corner of Sparta, just east and south of the intersection of the Grand Trunk and Pere Marquette Railroads in the center of Section 14, T. 9 N., R. 12 W. The clay runs about 11 feet deep and then goes to quicksand, at least in places. Digging is done by a steam shovel which loads the skip cars directly. The cars are drawn up from the pit by a power driven drum, and dumped into a pug mill where the clay is tempered. The clay is then passed through rolls into the auger extrusion machine. Drain tile and building tile are manufactured. The drier is heated by separate fires and by steam coils supplied from the steam power plant. Burning is done in four thirty foot round downdraft kilns.

When the plant was visited in July, 1922, it was closed. Local information reported the shut down was due to the difficulty of obtaining labor. Rather hasty observation of some tile on the property indicated that the clay was dug in a rather careless manner, i. e., quick sand

and top soil was included in the clay to the detriment of the product. The tile were generally buff to salmon, with some red tile around the bag walls where the fire gases first struck the ware. Sample 29 was taken from the clay pit.

Burning Test

Sample No. 29. Field Sheet No. 28.
Section 14 (center) T. 9 N., R. 12 W.
Plasticity .331 gm. water per gm. clay.
Average linear drying shrinkage 12.1 per cent.
Average tensile strength about 100 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	950	.394	1.3 %	Soft burned.....	Salmon
08	990	.388	1.3	Soft burned.....	Salmon pink
06	1,030	.400	2.0	Soft burned.....	Cream
04	1,070	.401	2.8	Soft burned.....	Cream
02	1,110	.333	4.0	Soft burned.....	Cream
1	1,150	.143	9.7	Hard burned.....	Olive
3	1,190	.075	11.1	Hard burned.....	Dark olive
5	1,230	.040	13.0	Hard burned.....	Dark olive
7	1,270	.035	8.1	Over burned.....	Olive

Molded easily; suitable for brick and tile.
Burned by H. W. Jackman.

The Grand Rapids Clay Products Company operates a modern brick plant at the eastern edge of Grand Rapids about one-fourth mile south of the Grand Trunk Railroad in the NW¼ Section 28, T. 7 N., R. 11 W. This plant has had a rather checkered history. When the clay pit was first opened the overburden of fine sand was not removed properly and became mixed with the clay. This practice made the production of a first class brick impossible, and the poor quality product could not be sold. The plant then changed hands and was heavily mortgaged. A second failure placed the property in the hands of the present owners, the Federal Life Insurance Company, who are sparing no pains or expense to make it a first class plant.

The clay deposit was originally about 40 acres in extent, one-half of which has been dug over. The heavy blue clay is covered by about five feet of fine sand and soil which must be removed before the clay is dug. Under the clay, which runs about 20 feet thick there is a somewhat coarser sand that is used to temper the clay. Sample No. 28 was taken from the clay pit.

Burning Test

Sample No. 28. Sheet 27.
Section 28, (NW Corner) T. 7 N., R. 11 W.
Plasticity .257 gm. water per gm. clay.
Linear drying shrinkage 6.7 per cent.
Average tensile strength about 102 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Fired Linear Shrinkage.	Hardness.	Color.
08	990	.445	2.6 %	Soft burned.....	Pink
06	1,030	.453	1.4	Soft burned.....	Cream
04	1,070	.465	0.7	Soft burned.....	Cream
02	1,110	.454	1.8	Soft burned.....	Cream
1	1,150	.428	4.3	Hard burned.....	Cream
3	1,190	.328	8.2	Hard burned.....	Tan
5	1,230	.291	10.0	Hard burned.....	Olive
7	1,270	.045	16.5	Vitrified.....	Olive
9	1,310	....	....	Melted	

Cracked slightly at the higher temperatures. Easily molded, good material for cream or buff tile and brick.
Burning test by H. W. Jackman.

The clay is dug by a steam shovel and loaded with a small amount of sand into narrow gage cars which are drawn to the plant by a small gasoline engine. The clay is dumped directly into a pug mill and tempered with water and some ground burned clay that is prepared by grinding bats in a dry pan. The tempered clay then passes through rolls into the auger machine equipped with a twin die for extruding brick. The green brick are stacked on trucks and pushed through a continuous tunnel drier which is heated directly by the hot gases from the boiler furnace. These stack gases are drawn from the boiler through a large flue along the side of the drier and blown into the exit end of the drier by a fan. The hot gases enter near the floor of the drier and come into contact with the nearly dry brick, ready to be removed, and do not reach the wet brick at the charging and until the gases have become more nearly saturated and cooled by their passage through the drier. At the charging end of the drier these gases escape through wooden stacks. The drying tunnels are also equipped with steam coils for auxiliary heating. This drying equipment cost $30,000 in 1921 and has increased greatly the capacity of the plant.

The dried brick as they leave the drier are covered with soot from the furnace gases, but this burns off in the kilns and causes no difficulty. The brick are burned in eight scove kilns of about 65,000 brick each. The product is a buff building brick of good quality. In 1923, when the plant first produced a good brick, the hard dark brick were being sold as sewer brick, but it would be impossible to produce satisfactory vitrified brick from this clay as a main product.

Under good conditions the capacity of the plant will approach 80,000 to 100,000 brick a day with a force of 55 men or more.

A sample of clay (189) submitted by the Ponce de Leon Water Company from Section 9, T. 6 N., R. 11 W., near East Paris, is red burning and would be good material for brick and tile if the pebbles it contains can be satisfactorily handled. It has a good commercial color and a burning range of 6 cones

Burning Test

Sample No. 189.
Section 9, T. 6 N., R. 11 W.
Plasticity .270 gm. water per gm. clay.
Average linear drying shrinkage 9 per cent.
Average tensile strength about 125 lbs. per sq. in.
Average apparent Sp. Gr. (dry) 2.47.

Cone No.	Thermo-couple °C. Temp.	Porosity.	Linear Shrinkage.	Hardness.	Color.
08	950	.386	1.0 %	Soft burned.....	Salmon
06	1,000	.388	1.4	Soft burned.....	Salmon
04	1,050	.354	2.0	Hard burned.....	Salmon
02	1,120	.275	6.5	Hard burned.....	Salmon
1	1,175	.092	9.8	Hard burned.....	Dark brown
3	1,220	.057	14.2	Vitrified.....	Chocolate brown
5	.....	....	....	Viscous	

Good material for brick and tile except for pebbles which may cause trouble.

Burned by Mark Huck.

The blue shales of the Grand Rapids Series associated with the gypsum were investigated by Ries* in 1900. His report includes samples taken at the shaft of the Powers Plaster Company (R216) and at the quarry of the Alabastine Co. (R227).

The shale from the Powers Plaster Co. (R216) was a dense, brownish gray shale, containing but little mica and no pyrite. It slaked very slowly, and mellowed slowly when simply exposed to the air.

Soluble salts, 0.9%.
Water of plasticity, 26%.
Air shrinkage, 6%.
Tensile strength, 130-155 lbs. sq. in.

Cone.	Total Shrinkage.	Burned.	Color.
05.....	12 %	Hard.....	Red
2.....	....	Vitrified	.....
6.....	....	Viscous	.....

*Mich. Geol. Survey VIII, p. 39, Pt. I.

The sample from the Alabastine Co. (R227) was taken from a shale bed seven feet thick overlying the gypsum. The shale itself was covered by three feet of drift. This shale was formerly used in the manufacture of common brick by the stiff mud process. The shale was spread out under a shed to dry and slake, then ground in a dry pan, tempered, and extruded. This shale is similar to that from the Powers Plaster Co.

Sample R227 ground to 30 mesh.
Water of plasticity, 32%.
Air shrinkage, 6%.
Tensile strength, 105 lbs. per sq. in.
Soluble salts, 0.9%.

Cone.	Total Shrinkage.	Burned.	Color.
05.....	12 %	Hard burned.....	Red
01.....	16 %	Vitrified	
3.....	....	Viscous	

In drying a white scum was formed on the surface by the soluble salts.

Chemical Analysis (Sample R227)

Silica (SiO_2)	56.50%
Alumina (Al_2O_3)	19.31
Iron (Fe_2O_3)	5.89
Lime ($CaCO_3$)	1.00
Magnesia ($MgCO_3$)	1.85
Alkalies (K_2O)	5.98
Difference	9.47
Ferrous Iron (FeO)	1.34

By A. N. Clark.

Compare this analysis with the following analysis of surface clay from Grand Rapids by S. P. Sharpless.*

Silica (SiO_2)	58.70%
Alumina + Iron ($Al_2O_3 + Fe_2O_3$).....	25.95
Lime (CaO)	1.00
Magnesia (MgO)	.74
Alkalies	5.54
Water, etc.	8.07

Generally the shale is found in a stratum about 23 inches thick overlying the gypsum at a depth of 95 feet for an area of about 50 square miles. Sample 27 was taken from this stratum in section 3, T. 6 N., R. 12 W., about one mile southwest of Grand Rapids city limits on the Pere Marquette railroad.

*16th Ann. Rept. Director U. S. Geological Surv., Part IV, p. 566.

Burning Test

Sample No. 27.
Section 3, T. 6 N., R. 12 W.
Plasticity .325 gm. water per gm. clay.
Average linear drying shrinkage 10.6 per cent.
Average tensile strength about 66 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	950	.295	1.1	Soft burned.....	Light red
08	990	.231	2.0	Soft burned.....	Light red
06	1,030	.192	3.8	Hard burned.....	Red
04	1,070	.058	7.6	Hard burned.....	Red
02	1,110	.068	4.6	Vitrified.....	Red brown
1	1,150	.329	−28.4	Over burned.....	Dark brown

Molded easily. Samples swelled at cone 03.
Burned by H. W. Jackman.

This blue shale is very suitable for brick or tile, but it is relatively inaccessible and thin.

LAKE COUNTY

Lake County is covered with morainic boulder clay, most of which is useless but may be locally usable for brick and tile. It is very similar to the clay near Branch, Mason County, (sample 1017). The Great Northern Cement Company, organized in 1899 as a New Jersey corporation, with $5,000,000 capitalization, built a plant of 24 kilns just south of Baldwin in Marlboro. This company was to use the clay bank in section 10, T. 17 N., R 12 W., which covers some 400 acres of a glacial deposit about 80 to 120 feet high. It is reported to be free from grit.

LAPEER COUNTY

The boulder clay near Elba was used for some time by the Elba Tile Company. The lake clay near Lapeer was formerly used to make common red brick.

About four miles north of Almont on Mark Farley's farm along the south side of the Belle River in Section 34, T. 7 N., R. 12 E., there is about six to eight feet of sandy yellow clay overlying about 25 feet of blue clay. This deposit covers 40 or 50 acres. Farther east and north of the river the blue clay is exposed on the surface. The clay is a lake clay similar to that found down the river to the east. Sample 151 was taken from the brown surface lake clay south of the Belle River.

Burning Test

Sample No. 151. Field Sheet 168.
Section 34, Southern, T. 7 N., R. 12 E.
Plasticity .234 gm. water per gm. clay.
Average linear drying shrinkage 6.3 per cent.
Average tensile strength about 97 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.339	−0.4 %	1.65	Soft burned.....	Pale salmon
08	990	.347	−0.2	1.65	Soft burned.....	Pale salmon
06	1,030	.349	−0.2	1.65	Soft burned.....	Pale salmon
04	1,070	.333	+0.6	1.68	Soft burned.....	Pale salmon
02	1,110	.149	6.3	2.02	Hard burned.....	Light brown
1	1,150	.094	7.9	2.13	Hard burned.....	Brown
3	1,190	.029	6.7	2.04	Vitrified.....	Dark brown
5	1,230	....	...	....	Viscous	

Light brown clay. Burned samples at Cones 02 and 1 have white edges, suitable for brick and tile.
Burned by H. W. Jackman.

LEELANAU COUNTY

Leelanau County is completely covered with glacial drift and sandy lake deposits. About three miles north of Traverse City and just west of the lake shore road in section 28, T. 28 N., R. 11 W., there is a ten acre deposit of blue clay about 20 to 25 feet deep in the form of a mound, covered in places by two to five feet of fine sand and underlain by a coarser sand. The deposit was formerly worked by James W. Markham, making good quality, stiff mud brick, of cream color. The plant is a total ruin and all of the machinery removed.

Chemical Analysis

Sample No. 34. Field Sheet 35.
Sample is a mixture from 5, 10, 15, 20 feet diggings in face of a clay bank in section 28, T. 28 N., R. 11 W.

Loss on Ignition	20.08%
SiO_2	34.95
Al_2O_3	14.05
Fe_2O_3	3.50
CaO	18.60
MgO	6.66
$Na_2O + K_2O$	2.16

Analysis by H. W. Jackman.

Burning Test

Sample No. 34. Field sheet No. 35.
Sections 28, 33, T. 28 N., R. 11 W.
Plasticity .286 gm. water per gm. clay.
Average linear drying shrinkage 9.2 per cent.
Average tensile strength about 130 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
08	990	.452	0.9 %	Soft burned.....	Cream
06	1,030	.464	1.3	Soft burned.....	Cream
04	1,070	.474	2.0	Soft burned.....	Cream
02	1,110	.464	2.4	Soft burned.....	Cream
1	1,150	.457	2.4	Soft burned.....	Cream
3	1,190	.372	7.7	Hard burned.....	Light olive
5	1,230	.103	15.9	Hard burned.....	Olive
7	1,310	....	....	Melted	

Molded easily. Suitable for brick or tile.
Burned by H. W. Jackman.

The analysis and burning test of this clay are very suggestive of the clay in the Long Lake series or Thunder Bay Series of the Traverse Formation* which forms the bed rock of the northwestern part of Leelanau and Benzie Counties. It seems probable that this glacial clay may have been derived at least in part from these shales.

LENAWEE COUNTY

Many of the clays of Lenawee County seem to have been derived in considerable part from the Coldwater and other shale formations which underlie the major part of the county. Lake clay is found east of Macon, Tecumseh, and the Detroit, Toledo & Ironton R. R.

The American Brick & Tile Company (B. A. Claypole) and M. F. Fairbanks operate tile plants at the western limits of Morenci in Section 6, T. 9 S., R. 2 E. The clays are practically identical lake clays in both pits and make a first quality red tile.

The American Brick and Tile Company is on the south side of the L. S. & M. S. Railroad. The section of the clay bank is as follows:

6 to 8 feet of red clay.
3 feet of blue clay.
1 in. sandstone.
Coarse sand

About two acres have been dug over so far and little more seems available as the village occupies the land surrounding the pit. The plant was apparently closed in 1922 because of exhaustion of its clay deposit.

*See sample 133 Alpena County and analysis of clay in limestone at Rockport, Alpena County.

This yard is quipped with

Steam power.
Steam shovel.
Pug mill.
Rolls.
Auger tile machine making drain tile and building tile.
Small air drying shed.
Fire drier and
Four 30 foot down draft kilns.

M. F. Fairbanks' plant is just north of the L. S. & M. S. Railroad. Here the clay section is reported as

8 ft. red clay.
1 in. sandstone.
60 feet blue clay (sample 61).

The plant is run by electric power and consists of:

Pug mill.
Brewer tile, auger machine, with cut off.
Open shed air driers.
One 20-ft. and one 30-ft. coal fired down draft kiln.

Mr. Fairbanks turns out a first class tile of salmon color. He claims to be able to dry the clay very rapidly by placing it in the sun without injury to the tile.

Sample 61 is representative of the blue clay used in both plants at Morenci. The red clay burns to a deeper color but is otherwise similar.

Burning Test.

Sample No. 61. Field Sheet No. 67.
Section 6, T. 9 S., R. 2 E.
Plasticity .320 gm. water per gm. clay.
Average linear drying shrinkage 9.8 per cent.
Average tensile strength about 126 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.385	0.0 %	1.52	Soft burned.....	Salmon
08	990	.426	1.4	1.57	Soft burned.....	Cream salmon
06	1,030	.405	1.0	1.55	Soft burned.....	Cream salmon
04	1,070	.405	2.0	1.50	Soft burned.....	Cream salmon
02	1,110	.289	4.5	1.76	Hard burned....	Very light brown
1	1,150	.020	13.6	2.32	Vitrified.....	Olive brown
3	1,190	.037	12.0	2.16	Vitrified.....	Olive
5	1,230	....	....	....	Viscous	

Easy to mold. Suitable for common brick or tile.
Burned by H. W. Jackman.

About 1887 in the neighborhood of two miles east of Packard, Section 13, T. 8 S., R. 2 E., north of the river, lake clay was used to make brick.

Lewis Ruff operated a brick and tile plant some years ago about ¾ mile south of Jasper, just east of the main road (M-52) in NW¼ section 14, T. 8 S., R. 3 E. All the machinery has been dismantled and removed. All that is left is the wrecked down draft kiln, the drying shed, and the two stacks. The clay pit lies to the south of the yard in a bank of red clay about 12 to 15 feet deep at the greatest depth, and covering 15 acres or more. The clay is somewhat pebbly, particularly in the upper red strata, and grades to blue clay at the bottom. The brick and tile were of good quality and had a good red color.

Sample 60 was taken from the old pit. The analysis and burning properties suggest that this clay was derived from the shale formations which underlie this part of the State.

Burning Test.

Sample No. 60. Field Sheet No. 65.
Section 14, T. 8 S., R. 3 E.
Plasticity .264 gm. water per gm. clay.
Average linear drying shrinkage 9.6 per cent.
Average tensile strength about 155 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.308	−0.4 %	1.73	Soft burned.....	Salmon
08	990	.321	0.0	1.74	Soft burned.....	Salmon
06	1,030	.336	+0.8	1.76	Soft burned.....	Salmon
04	1,070	.301	1.4	1.81	Soft burned.....	Light red
02	1,110	.227	3.8	1.94	Hard burned....	Red
1	1,150	.117	6.5	2.14	Hard burned....	Dark red brown
3	1,190	.045	6.5	2.12	Vitrified.....	Chocolate
5	1,230	.038	5.1	2.06	Vitrified.....	Chocolate
7	1,270	....	...	....	Viscous	

Brown clay containing lime and other pebbles. Suitable for face brick and tile if trouble from pebbles can be overcome. Molded easily.

Burned by H. W. Jackman.

Chemical Analysis.

Sample 60. Sheet 65.
Section 14, T. 8 S., R. 3 E.

Ignition Loss	9.80%
Silica SiO_2	58.90
Ferric Oxide Fe_2O_3	4.26
Alumina Al_2O_3	17.24
Lime CaO	5.60
Magnesia MgO	2.57
Sulphur Trioxide So_3	Trace
Alkalies	1.25
Total	99.64

Analysis by Wm. Kane, Penin. Portland Cement.

C. H. Wilt made tile at Ogden Center, Section 21, T. 8 S., R. 4 E., until his death in 1920. The plant is fairly intact and owned by Mrs. Wilt of Blissfield. The clay is a somewhat stony red clay, apparently similar to that used near Jasper, (sample 60).

A Mr. Rupp made brick some years ago from the lake clay just north of Riga in sections 3-4, T. 8 S., R. 5 E., just north of the L. S. & M. S. Railroad. The property now comprises part of Snyder's farm.

A Mr. Bliss operated a brick yard just east of Blissfield in NE¼ section 32, T. 7 S., R. 5 E., about 1-3 mile north of the railroad about 1890. The clay is very similar to that used by J. S. Saxton & Son until 1907, in SE¼ section 36, T. 7 S., R. 5 E., just northwest of the four corners three miles east and ¾ mile north of Riga. At the latter yard the clay is light gray in color and about 8 to 10 feet thick under four feet of black loam and lime pebbles, and covers about 20 acres. They made a fairly good brick and tile of a salmon color. Saxton & Son stopped operations apparently because of labor troubles.

Just north of the Raisin River at the river bend about the central part of section 21, T. 7 S., R. 5 E., there is a deposit of blue clay covered by a little sand. The river bed is also clay. This blue clay was used by W. T. Atkins until about 1915 to make soft mud brick and drain tile. The clay made first class buff brick and tile, but according to reports, it is exhausted.

Two and one-half miles northeast of Adrian on Bailey's farm SE¼ section 24, T. 6 S., R. 3 E., a number of clay samples were taken. South of the D. T. & I. R. R., and just north of the creek in the south central part of the section there is a knoll which was drilled on the south and north sides with the following results:

South Side.	North Side.
4 ft. top soil.	8 ft. sand.
2 ft. red brown sand.	14 ft. sand.
18 inches light brown sand.	Water.

4 feet light brown boulder clay. (Samples 301 and 302).
Blue boulder clay possibly Pre-Wisconsin till. (Sample 303).

Analysis.

Sample 303. Sheet 210. Section 24, T. 6 S., R. 3 E.

Loss on Ignition	15.10%	15.21%	15.16%
Silica (SiO_2)	46.26	46.38	46.32
Alumina (Al_2O_3)	10.01	10.01	10.01
Titania (TiO_2)	0.36	0.36	0.36
Lime (CaO)	5.97	6.06	6.03
Magnesia (MgO)	4.85	4.81	4.83
Iron (Fe_2O_3)	1.47	1.46	1.47
Alkalies (Na_2O, K_2O)	14.76	14.98	14.87

Analysis by Sutton.

Burning Test.

Sample No. 302. Field Sheet No. 210.
Section 24, T. 6 S., R. 3 E.
Plasticity .189 gm. water per gm. clay.
Average linear drying shrinkage 6.0 per cent.
Average tensile strength about 85 lbs. per sq. in.
Dry porosity .228.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	916	.416	0.8 %	Soft burned.....	Salmon
08	950	.392	−0.4	Soft burned.....	Salmon
06	1,000	.323	−0.8	Soft burned.....	Salmon
04	1,050	.313	−0.2	Hard burned.....	Salmon
02	1,120	.308	5.0	Hard burned.....	Cream salmon
1	1,175	.206	7.3	Hard burned.....	Olive
3	1,220	.082	12.2	Hard burned.....	Olive
5	.....	....	....	Viscous	

Yellow brown clay with lime pebbles causing lime pops.
Burned by Mark Huck.

Burning Test.

Sample No. 303. Field Sheet No. 210.
Section No. 24, T. 6 S., R. 3 E.
Plasticity .163 gm. water per gm. clay.
Average linear drying shrinkage 4.6 per cent.
Average tensile strength about 85 lbs. per sq. in.
Dry porosity .246.

Cone No.	Temp. °C. by Thermocouple.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	916	.380	0.0 %	Soft burned.....	Salmon
08	950	.421	1.8	Soft burned.....	Cream salmon
06	1,000	.433	4.6	Soft burned.....	Cream salmon
04	1,050	.356	8.0	Hard burned.....	Cream salmon
02	1,120	.270	9.2	Hard burned.....	Gray
1	1,175	.236	12.4	Hard burned.....	Olive
3	1,220	.100	14.8	Hard burned.....	Olive
5	.....	....	....	Viscous	

Blue clay with lime pebbles, lime pops.
Burned by Mark Huck.

On the northwest side of the railroad about the center of section 24 there are 20 acres of brown clay running about 3 to 5 feet deep. Samples 304, 305, 306, and 307 were taken at various points in the deposit, mixed and tested.

Burning Test.

Samples No. 304, 305, 306, and 307.
Section No. 24, T. 6 S., R. 3 E., Lenawee County.
Plasticity .227 gm. water per gm. clay.
Average linear drying shrinkage 8.5 per cent.
Average tensile strength about 110 lbs. per sq. in.
Dry porosity .236.

Cone No.	Temp. °C. by Thermocouple.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	916	.414	0.2 %	Soft burned.....	Light red
08	950	.360	−0.4	Soft burned.....	Light red
06	1,000	.356	1.0	Soft burned.....	Light red
04	1,050	.357	1.6	Soft burned.....	Light red
02	1,120	.357	5.0	Hard burned.....	Red
1	1,175	.160	6.9	Hard burned.....	Chocolate brown
3	1,220	.149	10.2	Vitrified.....	Chocolate brown
5	.....	....	....	Viscous	

Good material for brick and tile and might be used for face brick.
Burned by Mark Huck.

The Peninsular Portland Cement Company, organized June 24, 1899, with a capital of $875,000, completed their plant of 6 kilns, located at Cement City at the intersection of the C. N., L. S. & M. S. Railroads, section 5, T. 5 S., R. 1 E., in 1901. At that time marl from Silver Lake and clay from Millbury, Ohio, were used as the raw materials. The wet process is used.

The present plant is equipped with 3 bottle kilns 9 ft. in diameter in the lower section, 7 feet in diameter in the upper section, and 205 feet long, with a combined capacity of 2400 barrels a day. Limestone from Alpena and lime refuse from Wyandotte has superseded the marl.

Clay is obtained from a pit on the Deo farm 1½ miles south of Rollin and 12 miles south of the plant on the Cincinnati & Northern Railroad in NE¼ section 5, T. 7 N., R. 1 E. The clay bank is about 12 to 15 feet thick with compact coarse gravel and sand at the bottom.

Five samples from the lower four feet of the deposit:

Silica SiO_2	44.90%	48.90%	46.60%	43.60%	47.20%
Iron Fe_2O_3	5.39	4.97	5.11	5.11	5.08
Alumina Al_2O_3 ..	15.31	18.93	17.09	15.69	17.72
Lime as CaO ...	13.00	10.10	10.60	10.90	10.50
Magnesia MgO..	3.67	3.90	3.83	3.62	3.11
Ignition Loss ..	16.65	14.85	15.05	15.10	14.75
Total	99.92	99.65	98.18	94.02	98.96
Color.....	Blue / White	Yellow / Blue	Yellow / Blue	Yellow / Blue	Yellow / Blue

Analyses by W. Kane, Peninsular Portland Cement Co.

The average analysis of the upper 8 to 10 feet is as follows:

Loss on Ignition	9.5 %
Silica (SiO_2)	59.44
Alumina (Al_2O_3)	14.6
Ferric Oxide (Fe_2O_3)	6.02
Lime (CaO)	6.56
Magnesia (MgO)	2.91

Burning Test.

Sample 187 from the lower part of this deposit.
Section No. 5, T. 7 N., R. 1 E.
Plasticity .306 gm. water per gm. clay.
Average linear drying shrinkage 5.5 per cent.
Average tensile strength about 132 lbs. per sq. in.
Average apparent Sp. Gr. 2.74.

Cone No.	Thermo-couple Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	905	.431	0.5 %	2.95	Soft burned.....	Salmon
08	945	.431	0.9	2.89	Soft burned.....	Salmon
06	995	.425	1.2	2.90	Soft burned.....	Salmon
04	1,045	.410	1.5	2.90	Hard burned....	Salmon pink
02	1,090	.362	2.3	2.72	Hard burned....	Salmon pink
1	1,130	.342	6.2	2.94	Hard burned....	Grayish cream
3	1,170	.015	7.4	2.13	Vitrified.....	Cream
5	1,210	....	....	....	Melted	

Blue clay intermixed with red. Free from lime and pebbles. Easily molded.

Burned by M. C. Huck.

There is a deposit of blue clay on the Binns farm across from N. A. Saunders' old brick yard at Addison Junction, about 150 feet west of the C. N. Railroad track, and about 30 rods north of the C. N. depot, Sec. 32, T. 5 S., R. 1 E. The deposit extends west about 20 rods and north to a marsh. The north part contains considerable sand and gravel. All told there is about 20 acres of grit-free blue clay with a depth of over 40 feet. This deposit was sampled and analyzed by Mr. Kane.

	Blue Clay Binns Farm	Yellow Clay 300 feet west of Brick Yard	Yellow Tile from Brick Yard
Silica SiO_2	49.08%	55.54%	56.50%
Alumina Al_2O_3	10.73	10.72	16.80
Iron Fe_2O_3	3.55	4.84	16.80
Lime CaO	14.04	9.85	9.10
Magnesia MgO	4.66	4.12	3.36

Another old brick yard is on the south side of town but no samples were taken or data collected. There is a large clay bank or hill of yellow clay on the south side of town.

LIVINGSTON COUNTY.

Some of the surface clays of Livingston County bear evidence of being derived from the Coal Measures shales. Sample 156 of the upper 7 feet of red boulder clay south and southwest of Howell in section 23, T. 2 N., R. 4 E., has a wide burning and vitrification range and is good material for face brick, tile, and vitrified ware. In many other places in the area through sections 2, 11, 14, and 23 this clay is free from stone and very usable.

Burning Test.

Sample No. 156. Field Sheet No. 156.
Section 23, T. 2 N., R. 4 E.
Plasticity .314 gm. water per gm. clay.
Average linear drying shrinkage 12.2 per cent.
Average tensile strength about 148 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.299	0.6 %	1.79	Soft burned.....	Salmon
08	990	.301	1.5	1.83	Soft burned.....	Light red
06	1,030	.266	2.5	1.89	Hard burned....	Red
04	1,070	.195	4.9	2.04	Hard burned....	Red
02	1,110	.070	8.8	2.30	Vitrified.....	Chocolate
1	1,150	.053	9.4	2.32	Vitrified.....	Chocolate
3	1,190	.026	8.3	2.28	Vitrified.....	Chocolate
5	1,230	.024	6.5	2.16	Vitrified.....	Chocolate
7	1,270	.023	+4.6	1.99	Vitrified.....	Chocolate
9	1,310	.222	−2.8	1.64	Vitrified.....	Chocolate brown

Yellow brown clay. Easy to mold. Suitable for brick, tile, face brick, and vitrified ware.

Burned by H. W. Jackman.

The Standard Portland Cement Company organized November 15, 1900, with a capital of $1,000,000, proposed to use the clay and marl near Lakeland, T. 1 N., R. 5 E. The following analyses* of a clay were made for this company:

	Brick yard Pinckney	Local clay Lakeland
Loss on Ignition	12.44%	5.55%
Silica (SiO_2)	54.94	62.55
Alumina (Al_2O_3)	12.14	17.40
Ferric Oxide (Fe_2O_3)	4.88	5.08
Lime (CaO)	9.13	2.30
Magnesia (MgO)	3.65	1.69
Sulphur Trioxide SO_3	None	Trace
Sand		3.76

*By Prof. E. C. Campbell, Russell 22nd Ann. Rept. U. S. Geol. Survey, Part III, p. 671 (1902) Mich. Geol. Survey VIII, Pt. III, p. 291.

In the northeastern part of the county one-quarter mile west of Runyan Lake in the western part of section 9, T. 4 N., R. 6 E., there is a large deposit of yellow brown glacial clay containing pebbles. Sample 152 is representative of this clay and also that farther to the east. The clay is from 10 to 35 or 40 feet thick and covers a large area.

Burning Test.

Sample No. 152. Field Sheet No. 169.
Section W. 9, T. 4 N., R. 6 E.
Plasticity .220 gm. water per gm. clay.
Average linear drying shrinkage 6.3 per cent.
Average tensile strength about 116 lbs. per sq. in.
Apparent Sp. Gr. dry 2.68.

Cone No.	Cone Temp. °C.	Porosity.	Lnear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.385	0.0 %	2.75	Soft burned.....	Salmon
08	990	.378	−0.6	2.63	Soft burned.....	Light salmon
06	1,030	.380	0.0	2.68	Soft burned.....	Light samlon
04	1,070	.382	+0.4	2.73	Soft burned.....	Cream
02	1,110	.331	2.0	2.63	Hard burned.. .	Cream olive
1	1,150	.223	5.3	2.54	Hard burned....	Olive
3	1,190	.167	6.9	2.47	Vitrified.....	Olive
5	1,230	....	...	....	Viscous	

Brown clay. Easily molded.
Burned by H. W. Jackman.

MACOMB COUNTY.

Most of the clays of Macomb County are lake deposits. Only the lake clays have been worked. They are probably derived in considerable part from underlying shale formations. They burn to a very good color and are suitable for face brick. In some places they may be found suitable for vitrified ware.

About 4 miles east of Washington and ¾ mile south of Davis in section 31, T. 4 N., R. 12 E., East Gass operated a drain tile plant from 1894 to 1918. He has about 6 acres of blue clay, 3 acres of which is first class material for brick or tile. The clay is about 4 feet deep and then lime pebbles and marl appear in the clay. For this reason, and because drainage is difficult at greater depths, Mr. Gass never worked the deposits below 4 feet. There is a considerable amount of similar clay in the district, particularly to the east of his deposit.

Sample 15 was taken from some old unburned tile in the drying shed and is representative of the better clay of the district. The burning test shows it to be good material for brick or tile, and suitable for making front or face brick.

Burning Test.

Sample No. 15. Field Sheet No. 10.
Section 31, T. 4 N., R. 12 E.
Plasticity .362 gm. water per gm. clay.
Average tensile strength about 146 lbs. per sq. in.
Average linear drying shrinkage 16.3 per cent.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.324	0.7 %	1.71	Soft burned....	Salmon
08	990	.289	2.0	1.78	Soft burned...	Salmon
06	1,030	.222	4.6	1.94	Hard burned....	Light red
04	1,070	.149	7.1	2.07	Hard burned....	Red
02	1,110	.057	9.9	2.24	Vitrified.....	Dark red
1	1,150	.055	9.1	2.18	Vitrified.....	Chocolate red
3	1,190	.140	—4.4	1.48	Softening.....	Chocolate red

Brown clay. Easy to mold. Suitable for brick, tile, and may be used for face brick. Burned by H. W. Jackman.

The plant, which is in good repair, comprises:

Wood burning five tube boiler.
Engine.
Pugmill.
Tile extrusion auger machine.
Air drying shed 216 feet long with drop doors.
Rectangular Eudaly wood fired kiln.

Mr. Gass was never able to get adequate help. His wife often fired the boiler and kept all the machinery running and oiled, while he fed the pugmill and carried tile to the drier. From Tuesday to Thursday night he fired the kiln himself, getting a few minutes sleep between firings. His product was first class and always in demand. Farmers loaded their wagons themselves directly out of the kilns. Mr. Gass worked hard and was successful.

The Fries Tile Works in the SW¼ Sec. 8, T. 2 N., R. 12 E., 4½ miles southwest of Utica and 1½ miles west of the Michigan Central Railroad, formerly worked a lake clay deposit that is very similar to that of East Gass. The usable deposit covers 10 to 20 acres and is very similar to other deposits in the vicinity. At a depth of 3 feet the clay contains lime pebbles and has never been used below this depth.

For a number of years the Fries family, with what help they could get, worked the clay into drain tile. The plant was shut down in 1908, after the father died, primarily due to inability to get steady help. Local market conditions were always good. Farmers loaded their own wagons. The product was a good tile, light red in color.

The equipment, including wood burning fire tube boiler, auger machine, drying shed, and wood-fired down draft kiln, are in poor repair and gradually becoming a complete wreck.

Sample 14 was taken from the old clay pit and is representative of the lake clay in this vicinity.

Burning Test.

Sample No. 14. Field Sheet No. 9. SW¼ Section 8, T. 2 N., R. 12 E.
Plasticity .335 gm. water per gm. clay.
Average linear drying shrinkage 14.0 per cent.
Average tensile strength about 150 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.315	0.2%	1.71	Soft burned.....	Salmon
08	990	.296	1.6	1.80	Soft burned.....	Salmon
06	1,030	.250	3.8	1.91	Hard burned....	Salmon
04	1,070	.151	6.6	2.08	Hard burned....	Dark red
02	1,110	.104	7.5	2.14	Hard burned....	Chocolate red
1	1,150	.085	8.2	2.09	Vitrified.....	Chocolate red
3	1,190	.079	4.3	1.95	Vitrified.....	Chocolate red
5	1,230	.163	0.0	1.71	Overburned.....	Chocolate
7	1,270	....	...	....	Viscous	

Brown clay. Samples at Cones 06, 04, and 02 have white edges when burned. Suitable for face brick, tile, and possibly, sewer pipe, etc.

Burned by H. W. Jackman.

The Warren Brick Company is located just northeast of Warren on the west side of the Michigan Central Railroad, Sec. 4, T. 1 N., R. 12 E. This deposit has been worked 30 years, in which time about 20 acres have been dug over to a depth of 10 to 12 feet. The deposit is similar to the Detroit Clay beds and the section is:

1 to 3 ft. clean sand, used in molding.
7 to 8 ft. red clay.
4 ft. plastic heavy bluish clay.
Gravel and lime pebbles.

Sample 7 represents an average vertical section through the blue and red clay. The analysis suggests that this clay was derived in considerable part from the underlying shale formations. This conclusion is also borne out in the burning properties, which suggest that the sample is suitable for face brick or vitrified ware.

Chemical Analysis.

Sample No. 7. Field Report Sheet No. 15.
Of entire vertical section of deposit in section 4, T. 1 N., R. 12 E.

Loss on Ignition	9.03%
Silica SiO_2	51.88
Alumina Al_2O_3	19.94
Iron Fe_2O_3	6.24
Lime CaO	6.98
Magnesia MgO	3.37
Alkalies Na_2O K_2O	2.56

Analysis by H. W. Jackman.

Burning Test.

Sample No. 7. Field Sheet No. 15.
Section 4, T. 1 N., R. 12 E.
Plasticity .384 gm. water per gm. clay.
Average linear drying shrinkage 13.0 per cent.

Cone No.	Cone Temp. °C.	Porosity.	Linear Drying Shrinkage.	Hardness.	Color.
010	950	.400	0.0%	Soft burned.....	Salmon
08	990	.405	0.4	Soft burned.....	Salmon
06	1,030	.392	2.8	Soft burned.....	Light tan
04	1,070	.297	5.3	Hard burned.....	Tan
02	1,110	.021	11.8	Hard burned.....	Dark brown
1	1,150	.020	10.1	Vitrified.....	Dark brown
3	1,190	.249	11.3	Vitrified.....	Chocolate brown
5	1,230	.180	12.7	Vitrified.....	Chocolate brown
7	1,270	....	....	Melted	

Molded easily. White spots on surfaces of all samples. Suitable for dark face brick or possibly vitrified ware.

Burned by H. W. Jackman.

The clay is dug by a steam shovel taking a vertical section through the clay bank with each bucket, loaded into narrow gage dump cars which are drawn to the plant or loading platform by a gasoline dinkey. The Alliance Brick Co., 2½ miles south, also obtains its clay from this pit. In wet weather the pit is drained by a gasoline engine driven pump.

The entire plant except the drain tile equipment has been recently rebuilt. The clay is tempered in a pug-mill and molded in a six brick soft mud molding machine with a capacity of about 24,000 brick a day. The green brick are dried on pallets in open air drying racks which make it possible to run the plant only 4 or 5 months a year. The brick are thoroughly dried in a week and are burned in scove kilns. The operators intend (1922) to install a steam heated drier so that the plant may be run 12 months of the year instead of 4. The plant produces a hard red brick of first quality.

The drain tile equipment is in good condition except the updraft kiln.

Two miles south of Warren on the east side of the Michigan Central Railroad Jacob Hartsig formerly made brick in section 9, T. 1 N., R. 12 E.

Across the road in NE¼ section 16, just east of the railroad is the new plant of the Alliance Brick Company. This company has a well built soft mud brick plant of the type used in the Detroit district, but no workable clay. Clay is obtained from the pit of the Warren Brick Company 2½ miles north and brought to the plant in motor trucks.

The equipment is well laid out in a light spacious plant, and includes:

Pug-mill.
Full automatic seven brick soft mud molding machine, capacity 50,000 bricks a day.
Steam heated drier with conveyor for pallets.
Scove kiln shed.

The clay this company expected to use lies to the south and west of the plant. It is about 2 to 3 feet deep and contains lime pebbles. The clay makes a poor product, full of lime pops unless special care is taken to handle the clay to the best advantage as is done in the State plant at Onondaga. Rolls were installed with the idea of crushing the pebbles, but apparently without marked improvement. Clay from the Warren Brick Co. pit was then substituted. The product was much more satisfactory but could have been improved by making the machinery more adapted to the clay.

MANISTEE COUNTY.

Morainic clay is worked on a small scale by J. Kujawsky, 2½ miles south of Filer City on the highway. He has a few acres of red and blue stony clay about 350 yards east of the road, in Sec. 36, T. 21 N., R. 17 W. The clay is poor material, contains lime pebbles, and has little value. Kujawsky used this clay to make soft mud brick to build his home. The red clay in the upper part of the bed burns to a light red brick, and the blue clay making up most of the deposit burns cream. He now has a plunger stiff mud machine and expects to make some wire cut brick.

Farther north, near Onekama, about one-quarter mile east of Portage Lake, in section 36, T. 23 N., R. 16 W., Ernest Klein works a deposit of blue lake clay, single handed. On his property the clay is 200 feet deep under about two acres. The same kind of clay is found throughout the Onekama vicinity. Klein uses a plunger machine very similar to that used by Kujawsky, with which he can produce 2,000 brick or 1,500 drain tile a day. The green ware is dried in a closed shed and burned in scove kilns. A steam tractor supplies what power is used. Klein's equipment does not work the clay properly to obtain the best product.

The analysis and burning properties of this clay are very similar to that of sample 33 from Harrietta. The clay from Onekama however has not been tested as a Fuller's earth.

Chemical Analysis.

Sample No. 40. Field Report Sheet No. 40.
Sample green bricks from clay, Sec. 36, T. 23 N., R. 16 W.

Loss on Ignition	14.26%
SiO_2	47.15
Al_2O_3	17.68
Fe_2O_3	4.32
CaO	11.95
MgO	1.80
Na_2O K_2O	2.84

Analysis by H. W. Jackman.

Burning Test.

Sample No. 40. Field Report Sheet No. 40.
Section 36, (North) T. 23 N., R. 16 W.
Plasticity .316 gm. water per gm. clay.
Average linear drying shrinkage 13.6 per cent.
Average tensile strength about 200 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
08	990	.386	1.4%	Soft burned	Light pink
06	1,030	.394	1.1	Soft burned	Cream
04	1,070	.396	2.2	Soft burned	Cream
02	1,110	.373	3.2	Soft burned	Cream
1	1,150	.202	7.6	Hard burned	Tan
3	1,190	.032	13.0	Vitrified	Olive
5	1,230	.020	12.1	Vitrified	Olive
7	1,270	.021	12.4	Vitrified	Olive
9	1,310	....	....	Melted	

Molded easily. Very plastic. Suitable for brick and tile or pottery.
Burned by H. W. Jackman.

East of Arcadia running back about one mile from the shore of Lake Michigan is an old lake bed. The blue clay is at least 20 feet deep, and is covered by red clay and some gravel apparently washed down from the moraine hills farther east. Sample No. 38 is taken from the blue lake clay found in Sections 10, 11, 14, and 15, and sample 39 is of the red glacial clay running 60 to 80 feet deep in the hills of sections 11, 12, and 14, and covered in places with sand and gravel. The red clay has a better burning range than the lake clay but contains stone and lime lumps. Both are suitable for making brick and tile.

Chemical Analysis.

Sample No. 38. Field Report Sheet No. 39.
Upper 8 feet, by auger, of clay in section 10, T. 24 N., R. 16 W.

Loss on Ignition	8.46%
Silica (SiO_2)	65.64
Alumina (Al_2O_3)	9.16
Iron (Fe_2O_3)	2.47
Lime (CaO)	7.59
Magnesia (MgO)	3.58
Alkalies (Na_2O, K_2O)	3.10

Analysis by H. W. Jackman.

Burning Test.

Sample No. 38. Field Sheet No. 39.
Section 10, T. 24 N., R. 16 W.
Plasticity .168 gm. water per gm. clay.
Average linear drying shrinkage 4.2 per cent.
Average tensile strength about 100 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
08	990	.322	−1.1 %	Soft burned.....	Salmon
06	1,030	.322	−0.8	Soft burned.....	Pink
04	1,070	.334	−1.1	Soft burned.....	Pink
02	1,110	.322	−1.0	Soft burned.....	Pink tan
1	1,150	.295	0.6	Soft burned.....	Olive tan
3	1,190	.259	2.1	Hard burned.....	Light olive
5	1,230	.225	3.1	Hard burned.....	Olive
7	1,270	.196	3.7	Hard burned.....	Olive
9	1,310	....	...	Viscous	

Molded easily. Suitable for common brick or tile.
Burned by H. W. Jackman.

Burning Test.

Sample No. 39. Field Sheet No. 39.
Section 11, T. 24 N., R. 16 W.
Plasticity .306 gm. water per gm. clay.
Average linear drying shrinkage 10.8 per cent.
Average tensile strength about 150 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
08	990	.375	−0.5 %	Soft burned.....	Cream
06	1,030	.396	0.2	Soft burned.....	Cream
04	1,070	.386	1.1	Soft burned.....	Cream
02	1,110	.297	5.8	Hard burned.....	Tan
1	1,150	.214	6.0	Hard burned.....	Tan
3	1,190	.030	12.6	Hard burned.....	Olive brown
5	1,230	.038	10.4	Vitrified.....	Olive
7	1,270	.064	11.5	Vitrified.....	Olive

Molded easily. Contains lime lumps. These clays are probably suitable for brick and tile.

Burned by H. W. Jackman.

Chemical Analysis.

Sample No. 39. Field Report Sheet No. 39.
Upper 15 feet of clay in Section 11, T. 24 N., R. 16 W.

Loss on Ignition	9.57%
Silica (SiO_2)	52.80
Alumina (Al_2O_3)	17.76
Iron (Fe_2O_3)	3.27
Lime (CaO)	9.82
Magnesia (MgO)	4.44
Alkalies (Na_2O, K_2O)	2.34

Analysis by H. W. Jackman.

The Watervale Portland Cement Company organized by the same people who owned the Elk Rapids Co. and the Omega Co. proposed to erect a plant in this district and evidently planned to use some of this clay. None of the plans materialized.

MASON COUNTY.

Sample 1017 was taken from a deposit of glacial clay in the glacial outwash about ¾ mile west of Branch on the Pere Marquette Railroad. The clay is light colored, over 25 feet thick on more than 40 acres, and is covered with 3 to 4 feet of sand. The following burning test indicates that the clay may be used for making a soft burned porous brick or tile.

Burning Test.

Sample No. 1017. Field Sheet No. 1022.
Section 24, T. 18 N., R. 15 W.
Plasticity .264 gm. water per gm. clay.
Average linear drying shrinkage 9.0 per cent.
Average tensile strength about 175 lbs. per sq. in.
Apparent Sp. Gr. dry 2.53.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.385	+0.6 %	2.64	Soft burned.....	Salmon
08	990	.371	0.0	2.52	Soft burned.....	Cream salmon
06	1,030	.381	−1.5	2.46	Soft burned.....	Cream
04	1,070	.380	+1.8	2.66	Soft burned.....	Cream
02	1,110	.374	2.6	2.73	Soft burned.....	Very light olive
1	1,150	.308	6.2	2.72	Hard burned.....	Light olive
3	1,190	.017	10.4	2.20	Vitrified.....	Olive
5	1,230	....	....	....	Viscous	

Light brown clay. Molded easily.
Burned by H. W. Jackman.

A. A. Keiser of Ludington was formerly interested in a brick yard near the town. He reports the clay ran out some years ago and that he

knows of only one bank of any commercial possibilities in the county. In the south central part of section 31, T. 19 N., R. 17 W., just northwest of the bend in the road there is a bank of red clay about 25 feet thick that was sampled, and tested at Bucyrus, Ohio, where brick and tile were made from this clay. The brick and tile specimens are perfectly satisfactory. The clay through this district to the east of Hamlin Lake is probably the best in the county and is suitable for use in making brick and tile. Up the Big Sable River and southeast of Ludington the clay becomes very stony.

MECOSTA COUNTY

Mecosta County is covered with morainic boulder clay, and sand or gravel outwash. The boulder clay and the clay found with the outwash may be usable locally, but even this material is generally too stony to be of value.

In Big Rapids, on Milton Avenue, in the northeast part of the town, Section 2, T. 15 N., R. 10 W., W. F. Nehmer operates a brick yard making soft mud brick and tile, which is sold locally. The plant is driven by steam power and is equipped with rolls, pug mill, soft mud molding machine for brick, and two auger machines for extruding drain and building tile. The green ware is dried in the open air and burned in wood fired scove kilns. The clay deposit covers about 40 acres. There is three to four feet of red clay over about five to six feet of blue clay. This clay produces a good hard burned product at a low temperature, and has a wide burning range (over eight cones) that allows practically the entire kiln to be hard burned, without excessive failures or high fuel consumption. Because the clay is hard burned at a low temperature, it must be thoroughly oxidized before the temperature of burning is raised much above that necessary for water smoking.

Burning Test

Sample No. 31. Field Sheet No. 31.
Section 2, T. 15 N., R. 10 W. W. F. Nehmer, Milton Ave.
Plasticity .378 gm. water per gm. clay.
Average linear drying shrinkage 19.0 per cent.
Average tensile stress about 205 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	950	.246	1.0 %	Hard burned.....	Salmon
08	990	.187	2.9	Hard burned.....	Deep salmon
06	1,030	.181	...	Hard burned.....	Light red
04	1,070	.222	...	Hard burned.....	Red

Molded easily. Good material for common brick or tile but must be oxidized carefully. Burned by H. W. Jackman.

MIDLAND COUNTY

Midland County is covered by clay and sand deposited on the beds of the old glacial lakes which formerly covered this territory.

The northwest part of the county lying between the Pere Marquette railroad and the Tittabawassee River is largely clay. This clay is suitable for brick or tile if free from lime pebbles and in some places where the lime content is relatively low it shows possibilities of making a good hard burned red brick such as might be used for front or face brick. In general the lake clay throughout Arenac, Bay, Gladwin, Midland, Saginaw, and Tuscola counties is very similar.

Sample 85 was taken from the bank of the stream in the southeast corner of Section 25, T. 16 N., R. 1 W., just north of the bridge on the road two miles due north of North Bradley. This sample is generally typical of the clay in this district. It is a smooth red clay containing some lime pebbles and runs to a bluish clay at about 6 to 15 feet below the surface. Apparently the red clay was formed by leaching lime out of the blue clay and by the oxidation processes of weathering.

Burning Test

Sample No. 85. Field Sheet No. 90.
Section No. 25, T. 16 N., R. 1 W.
Plasticity .357 gm. water per gm. clay.
Average linear drying shrinkage 14.0 per cent.
Average tensile strength about 157 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.375	3.3	1.66	Soft burned.....	Pink
08	990	.412	2.3	1.61	Soft burned.....	Cream pink
06	1,030	.420	2.7	1.63	Soft burned.....	Cream
04	1,070	.396	4.0	1.69	Soft burned.....	Cream
02	1,110	.228	9.8	2.03	Hard burned.....	Very light olive
1	1,150	.022	14.1	2.38	Hard burned.....	Light olive
3	1,190	.023	16.1	2.48	Vitrified.....	Olive
5	1,230	.033	14.7	2.39	Vitrified.....	Olive
7	1,270	.020	12.7	2.24	Partly viscous...	Olive

Clay molded easily and is suitable for common brick and tile. It contains some lime pebbles. Burned by H. W. Jackman.

About one mile northwest of North Bradley on the Pere Marquette railroad and State Highway M-20 is the tile plant of R. W. D. Fish. On his property there is about 100 acres of good blue clay running about two and one-half to four feet deep. Below this depth, lime pebbles, three and one-half feet of red clay, and then quicksand are found. Sample 86 was taken from the upper blue clay which is used in the plant.

The plant consists of a Fate Tile Auger machine, a closed drying shed, one Stewart type 24-foot round down draft kiln, and the wreck of another kiln of the same kind. The plant produces drain tile and building tile and has a capacity of about 4,000 four inch tile a day.

The following test of this sample indicates that the clay may be considered good material for brick and tile. It might be used for the manufacture of hard burned red brick suitable for fronts or face brick if properly handled.

Burning Test

Sample No. 86. Field Sheet No. 91.

Section 1, T. 15 N., R. 2 W. Upper clay on property of R. W. D. Fish.

Plasticity .331 gm. water per gm. clay.

Average linear drying shrinkage, 16.9 per cent.

Average tensile strength about 223 lbs. per sq. in.

Heated for four hours to burn out carbon.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	450	.232	0.9	1.88	Soft burned.....	Salmon
08	990	.235	1.7	1.90	Hard burned....	Salmon red
06	1,030	.206	2.4	1.93	Hard burned....	Light red
04	1,070	.120	3.2	2.02	Hard burned....	Red
02	1,110	.092	2.7	1.97	Vitrified.....	Red brown
1	1,150	.109	−1.7	1.72	Vitrified.....	Red brown
3	1,190	.105	−6.5	1.79	Vitrified.....	Red brown
5	1,230	....	...	....	Viscous	

Light brown clay. Molds easily. Suitable for hard burned brick or tile and possibly face brick. Must be oxidized carefully.

Burned by H. W. Jackman.

About one mile north and one-half mile east of North Bradley the clay is covered by about three or four feet of sand and a layer of gravel. About seven feet below the top of the red clay is a few inches of quicksand and then more clay of the same kind, with a more bluish color. The following report of sample 87 represents the qualities of this clay:

Burning Test

Sample No. 87. Field Sheet No. 92.

Section 31 R. 1 W., between T. 15 N., and T. 16 N.

Plasticity .335 gm. water per gm. clay.

Average linear drying shrinkage 11.3 per cent.

Average tensile strength about 12 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.415	2.9 %	1.57	Soft burned.....	Salmon
08	990	.415	3.1	1.58	Soft burned.....	Cream
06	1,030	.425	3.3	1.60	Soft burned.....	Cream
04	1,070	.442	3.6	1.72	Soft burned.....	Cream
02	1,110	.394	6.0	2.25	Semi-hard burned.	Dark cream
1	1,150	.133	14.4	2.57	Hard burned.....	Light olive
3	1,190	.035	18.7	2.57	Vitrified.....	Olive
5	1,230	.024	17.9	2.07	Vitrified.....	Olive
7	1,270	.084	11.7	....	Overburned	

Red clay. Molded easily, but cracked easily on burning. Suitable for brick and tile. Burned by H. W. Jackman.

Along the east bank of the Tittabawassee River in Sections 1 and 2, T. 15 N., R. 1 W., is an outcrop of blue clay that seems very similar to the heavy blue clay found throughout this district (such as sample 170). Here the clay is exposed as a bank about 35 to 40 feet high.

In the southwest corner of Section 1, T. 16 N., R. 1 W., just south and east of the river fork, there is a flowing well which suggests clay beds in this area. The southeastern part of Midland County south of a line extending from Larkin south to Midland and thence southwest along the Chippewa river represents another large area that is chiefly clay.

The Midland Brick and Tile Company was formerly located just outside Midland about a mile and an eighth northwest of the center of the town and one-quarter mile northeast of P. M. R. R. in SW¼ Section 8, T. 14 N., R. 2 E. The plant shut down in 1910 after operating about three years. The clay runs about 15 feet deep, is yellow, red, and blue in color, and is covered by a little sand in some places. The following test of sample 141 taken from the old pit indicates that the clay is suitable for brick or tile:

Burning Test

Sample No. 141. Field Sheet No. 153.

SW¼ Section 8, T. 14 N., R. 2 E. Midland Brick and Tile Co.

Plasticity .252 gm. water per gm. clay.

Average linear drying shrinkage 7.7 per cent.

Average tensile strength about 137 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.394	0.6 %	1.56	Soft burned.....	Pink
08	990	.407	0.4	1.55	Soft burned.....	Pink
06	1,030	.405	0.8	1.58	Soft burned.....	Cream
04	1,070	.391	1.2	1.59	Soft burned.....	Cream
02	1,110	.389	1.9	1.62	Soft burned.....	Cream
1	1,150	.336	4.5	1.79	Hard burned....	Very light olive
3	1,190	.131	11.5	2.22	Hard burned....	Olive
5	1,230	.019	13.7	2.38	Vitrified.....	Olive
7	1,270	.009	13.7	2.40	Vitrified.....	Olive
9	1,310	....	....	....	Viscous	

Brown clay. Molded easily. Suitable for brick or tile.

Burned by H. W. Jackman.

There was formerly a brick yard on the present site of the Dow Chemical Company just north of the Pere Marquette Railroad in the NE¼ section 21, T. 14 N., R. 2 E. Mr. Woodworth, who drilled a well on this property for the Chemical Company, reports the clay to be 287 feet deep at this place, and not underlain by "hardpan" as is the clay two and one-half miles east in section 25.*

Three and one-third miles southeast of Midland on State Highway M-24 to Saginaw, one-half to three-quarters of a mile south of P. M. R. R.

*The map of surface formations published as Plate VII of the Mich. Geol. Survey, Pub. 25, Surface Geology of Michigan, by Frank Leverett, shows a waterlaid moraine just east of Midland and corresponding with the data reported above.

and on the east bank of the Tittabawassee river in sections 25, 26, 27, T. 14 N., R. 2 E., there is an outcrop of yellow and red clay that is also characteristic of the upper surface clay throughout Ingersoll Township (T. 13 N., R. 2 E). The upper five to six feet is red clay with a rectangular jointing and is represented by sample 172. Beneath there are eight inches of yellow clay (sample 173), and six to eight feet or more of mixed yellow and red clay (sample 174).

Burning Test

Sample No. 172. Upper six feet. Field Sheet No. 194.
Section No. 27, 26, 35, T. 14 N., R. 2 E.
Plasticity .296 gm. water per gm. clay.
Average linear drying shrinkage 9.9 per cent.
Average tensile strength about 160 lbs. per sq. in.
Apparent Sp. Gr. dry 2.65.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.379	2.0 %	2.65	Soft burned.....	Pink
08	990	.386	1.4	2.65	Soft burned.....	Cream
06	1,030	.390	1.4	2.65	Soft burned.....	Cream
04	1,070	.375	1.7	2.66	Soft burned.....	Cream
02	1,110	.349	4.9	2.76	Hard burned....	Cream
1	1,150	.167	8.7	2.50	Hard burned....	Light olive
3	1,190	.184	9.1	2.54	Hard burned....	Olive
5	1,230	.070	10.3	2.22	Softening.....	Olive
7	1,270	.068	8.3	2.12	Softening.....	Olive

Reddish brown clay containing lime pebbles. Molded easily.
Burned by H. W. Jackman.

Burning Test

Sample No. 174. Lower clay. Field Sheet No. 194.
Sections 27, 26, and 35, T. 14 N., R. 2 E.
Plasticity .210 gm. water per gm. clay.
Average linear drying shrinkage 6.2 per cent.
Average tensile strength about 106 lbs. per sq. in.
Apparent sp. gr. dry 2.64.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.412	0.0 %	2.75	Soft burned.....	Pink
08	990	.417	−1.3	2.76	Soft burned.....	Cream pink
06	1,030	.410	−2.3	2.68	Soft burned.....	Cream pink
04	1,070	.405	0.0	2.72	Soft burned.....	Cream pink
02	1,110	.369	+1.2	2.68	Soft burned.....	Very light olive
1	1,150	.323	2.2	2.68	Hard burned....	Light olive
3	1,190	.329	3.7	2.73	Hard burned....	Light olive
5	1,230	.055	11.0	2.45	Vitrified.....	Olive
7	1,270	....	....	....	Vitrified.....	Olive
9	1,310	....	....	....	Viscous	

Brown clay containing lime lumps. Molded easily.
Burned by H. W. Jackman.

These samples might be used for brick or tile but the lime pebbles would probably cause serious trouble.

Southeast of Midland in section 25, T. 14 N., R. 2 E., The Consolidated Coal Co. was sinking a shaft in 1923. There were 80 feet of "hardpan" and some red clay, then 20 feet of blue clay (sample 170) and water bearing sand at 100 feet. This clay is high in lime with a narrow burning range, and is similar to most of the surface clay in this district. It is suitable for making cream colored soft burned brick or tile.

Burning Test

Sample No. 170. Eighty to 100 feet deep. Field Sheet No. 190.
Section 25, T. 14 N., R. 2 E.
Plasticity .266 gm. water per gm. clay.
Average linear drying shrinkage 8.1 per cent.
Average tensile strength about 142 lbs. per sq. in.
Apparent Sp. Gr. Dry 2.63.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.381	2.0 %	2.67	Soft burned.....	Pink
08	990	.400	2.0	2.72	Soft burned.....	Cream
06	1,030	.412	1.0	2.71	Soft burned.....	Cream
04	1,070	.410	1.3	2.71	Soft burned.....	Cream
02	1,110	.404	2.3	2.78	Soft burned.....	Cream
1	1,150	.215	10.1	2.67	Hard burned....	Light olive
3	1,190	.173	15.8	....	Hard burned....	Olive
5	1,230	.025	10.3	2.16	Softening.....	Olive

Blue clay. Molded easily.
Burned by H. W. Jackman.

From 1891 to 1895, Woodworth used the clay in Section 25, T. 13 N., R. 2 E., northeast of Laporte, to make tile. The tile were burned in a round center stack kiln. The workings were abandoned because of poor market conditions. Woodworth reports he had some trouble with lime pebbles but that this was not serious. The same kind of clay is found in section 17 and also in T. 13 N., R. 1 E. Sample 171 was taken by trenching the side of a drainage ditch to a depth of eight feet in sections 16, 17, of T. 13 N., R. 2 E., and is typical of the district.

Burning Test

Sample No. 171. Field Sheet No. 193.
Section No. 16-17 (Center) T. 13 N., R. 2 E.
Plasticity .212 gm. water per gm. clay.
Average linear drying shrinkage 4.9 per cent.
Average tensile strength about 134 lbs. per sq. in.
Apparent Sp. Gr. dry 2.64.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.398	−0.9	2.68	Soft burned.....	Pink
08	990	.404	−0.1	2.68	Soft burned.....	Pink
06	1,030	.409	−0.2	2.71	Soft burned.....	Pink
04	1,070	.395	+0.7	2.75	Soft burned.....	Buff
02	1,110	.366	0.9	2.63	Hard burned....	Buff
1	1,150	.289	6.3	2.78	Hard burned....	Olive
3	1,190	.265	5.2	2.59	Hard burned....	Olive
5	1,230	.062	5.9	2.06	Vitrified.....	Olive
7	1,270	....	....	....	Viscous	

Brown clay containing lime pebbles. Easily molded.
Burned by H. W. Jackman.

MISSAUKEE COUNTY

About 1900 W. A. Minthorn made hand molded brick from clay on his property just south of Lake City on the railroad in Section 7, T. 22 N., R. 7 W. Sand was mixed with the clay in molding although good brick could be made from the clay alone. This brick, which is light in color, was used in constructing a church. Sample No. 1007 was taken from this deposit and seems to be suitable for cream colored common brick or tile.

Burning Test

Sample No. 1007. Field Sheet No. 1013.
Section 7, T. 22 N., R. 7 W., Reeder Township.
Plasticity 0.102 gm. water per gm. clay.
Average linear drying shrinkage 7.5 per cent.
Average tensile strength about 105 lbs. per sq. in.
Apparent sp. gr. of air dried sample 2.32.

Cone No.	Temp. of Pyrometer.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.450	0.0	3.03	Soft.....	Pink
082	952	.398	1.7	2.54	Soft.....	Pink
063	1,015	.456	−0.5	2.94	Soft.....	Cream
040	1,070	.407	+0.5	2.78	Soft.....	Cream
02	1,110	.424	1.1	2.96	Soft.....	Cream
1	1,150	.380	2.0	2.89	Hard.....	Light gray
3	1,195	.376	2.9	2.86	Hard.....	Olive gray
5	1,225	.287	3.3	2.78	Hard.....	Olive gray
7	1,250	.242	5.4	2.73	Hard.....	Olive gray

Light gray sandy clay free from lime pebbles.
Low plasticity. Burned by M. C. Huck.

On the south side of the village of McBain along the Ann Arbor Railroad, brick was made for some time previous to 1915. Nothing is left now but the pit covering about an acre on the property of Dennis Cotter. The old plant site is now occupied by a saw mill. The brick show white spots of limestone and are generally cream colored. When burned to a light red color the clay makes a brittle brick very similar to that made in Cadillac. This clay in section 30, T. 21 N., R. 7 W., is represented by sample 1006. Similar clay is found in a dredge cut two and one-half miles east and one-fourth mile south of the village where it is seen as a bank of red and blue clay about 15 to 20 feet deep covered by two to three feet of gravel.

Burning Test

Sample No. 1006. Field sheet No. 1012.
Section 30, T. 21 N., R. 7 W.
Plasticity 0.194 gm. water per gm. clay.
Average linear drying shrinkage 8.5 per cent.
Average tensile strength about 198 lbs. per sq. in.
Apparent Sp. Gr. of Air Dried Samples 2.22.

Cone No.	Temp. of Pyrometer.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.455	4.5 %	3.34	Soft.....	Salmon
08	952	.422	4.6	3.09	Soft.....	Salmon
06	1,015	.387	1.7	2.72	Soft.....	Salmon
04	1,070	.350	1.8	2.69	Soft.....	Salmon
02	1,190	.331	3.1	2.69	Hard.....	Red
1	1,150	Cracked on	firing	....	Hard.....	Red brown
3	1,195	Lime pop	Bloated	....	Vitrified.....	Chocolate
5	1,225	....	...	....	Viscous	

Light gray clay containing lime pebbles. Easy to mold.
Burned by M. C. Huck.

The presence of lime pebbles may make this clay useless; otherwise it is suitable for common brick or tile.

In the western part of the county in T. 23 N., R. 5 W., and T. 22 N., R. 5 W., there are some streaks of reddish boulder clay containing lime pebbles and running to sand in many places. The country is low and marshy and the clay of no value.

MONROE COUNTY

The surface clays of Monroe County are all lake or river clays and contain considerable lime. The burning properties of the red burning clay in Monroe County are very similar to the burning properties of the clays of Macomb County. These clays are good raw material for the manufacture of face brick or tile when free from lime pebbles, and in many places may be used for vitrified ware.

The Meyer Brothers operate a tile plant in Azalia, just west of the Ann Arbor railroad near the station, in the west central part of Section 25, T. 5 S., R. 6 E. The clay is about three to six or eight feet deep in pockets over about 160 acres along and north of Macon Creek. As the lower strata of clay contain limestone pebbles the upper three to five feet are stripped from the flats and hauled in wagons to the plant. The clay is a yellow red clay, plastic and rather free from grit. It burns to a good hard product, deep red in color. Sample 59 was taken from the stock pile at the plant. The burning test indicates that the sample is excellent material for face brick and tile and that it could be used for vitrified ware.

Burning Test

Sample No. 59. Field Sheet No. 60.
Section 25, T. 5 S., R. 6 E.
Plasticity .260 gm. water per gm clay.
Average linear drying shrinkage 10.3 per cent.
Average tensile strength about 172 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.292	0.0 %	1.82	Soft burned.....	Light red
08	990	.285	0.2	1.85	Soft burned.....	Light red
06	1,030	.272	0.9	1.89	Soft burned.....	Red
04	1,070	.240	2.1	1.95	Hard burned.....	Red
02	1,110	.184	4.0	2.09	Hard burned.....	Dark red
1	1,150	.125	6.1	2.24	Vitrified.....	Chocolate red
3	1,190	.048	6.4	2.24	Vitrified.....	Chocolate red
5	1,230	.046	5.9	2.22	Vitrified.....	Chocolate
7	1,270	.043	4.1	2.10	Softening slightly...	Chocolate

Yellow red clay. Easy to mold. Good material for face brick, tile, or vitrified ware. Burned by H. W. Jackman.

The clay is prepared, molded, and burned in the following equipment driven by steam power:

Roll crusher.
Pug mill.
Brewer auger extrusion machine for tile 3, 5, or 15 inches in diameter.
Three rectangular Eudaly kilns, coal fired.

The plant has a daily capacity of about 10,000 three inch tile. Market conditions are generally good. The plant was not running up to capacity in 1922 because of coal shortage. In 1923 there was so much road building that no labor could be obtained and the plant did not run at all. Normally 12 to 15 men are employed. The plant has been in operation since 1895.

About one and one-fourth miles northwest of Azalia just west of the Ann Arbor railroad, in NE¼ Section 23, T. 5 S., R. 6 E., the yellow clay runs about 10 to 12 feet deep and is underlain by blue clay of unknown depth. The yellow clay contains some pebbles and is generally similar to the clay used at Azalia. It was sampled (1035) by trenching in the side of a drainage ditch. The blue clay was sampled (1036) by drilling with the auger. This blue clay is found under the yellow clay throughout Monroe County and contains more lime. The analyses of the two clays are very similar except for the lime content as carbonate and sulphate.

Burning Test

Sample No. 1036. Field Sheet No. 1042. Section 23, T. 5 S., R. 6 E.
Plasticity .200 gm. water per gm. clay.
Average linear drying shrinkage 4.8 per cent.
Average tensile strength about 108 lbs. per sq. in.
Apparent Sp. Gr. dry, 2.54.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. G.	Hardness.	Color.
010	950	.394	−0.6 %	2.74	Soft burned.....	Salmon
08	990	.415	0.0	2.91	Soft burned.....	Light salmon
06	1,030	.386	−0.4	2.70	Soft burned.....	Light salmon
04	1,070	.391	0.0	2.75	Soft burned.....	Buff
02	1,110	.358	+1.1	2.70	Hard burned.....	Light brown
1	1,150	.211	6.7	2.59	Hard burned.....	Olive brown
3	1,190	.102	7.0	2.26	Vitrified.....	Olive
5	1,230	....	...	....	Viscous	

Blue clay with lime pebbles. Molded easily.
Burned by H. W. Jackman.

Chemical Analysis

Sample No. 1036. Field Sheet No. 1042. Section 23, T. 5 S., R. 6 E.

Ignition Loss	13.65%
Silica (SiO_2)	48.00
Ferric Oxide (Fe_2O_3)	2.80
Alumina (Al_2O_3)	13.90
Lime (CaO)	13.60
Magnesia (MgO)	3.61
Sulphur trioxide (SO_3)	1.42
Alkalies	2.84
Total	99.82%

The Maybee Brick & Tile Co. is on the D. T. & I. Railroad within the village limits of Maybee, in section 29, T. 5 S., R. 8 E. The plant made

tile chiefly, and shut down in 1921 because of a shortage of labor and coal. The railroad pays $5.00 to $6.00 a day for labor and the tile plant can get no one at $3.00 or $4.00, which is all that the company is willing to pay. The plant formerly employed six men to produce 8,000 to 10,000 brick or small tile a day. H. Leidel reports it is doubtful whether the plant will run again.

The clay is similar to that covering most of Monroe County. The company owns about 40 acres of clay which is covered by about two to three feet of sand. The clay has been used to a depth of five to six feet over about an acre. Sample 1038 was taken from the pit and seems to be suitable for all kinds of brick and tile.

Burning Test

Sample No. 1038. Field Sheet No. 1044.
Section 29, T. 5 S., R. 8 E., Twn Exeter.
Plasticity 0.191 gm. water per gm. clay.
Average linear drying shrinkage 8 per cent.
Average tensile strength about 135 lbs. per sq. in.
Apparent Sp. Gr. of air dried sample 2.36.

Cone No.	Temp. °C. by Thermo-couple.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.340	0.4%	2.73	Soft burned.....	Light red
08	952	.293	−3.0	2.25	Soft burned.....	Light red
06	1,015	.317	−0.1	2.74	Soft burned.....	Light red
04	1,070	.294	1.75	2.75	Hard burned....	Red
02	1,110	.234	3.1	2.66	Hard burned....	Dark red
1	1,150	.176	4.1	2.71	Hard burned....	Chocolate
3	1,195	Lime pop	...	....	Vitrified.....	Chocolate
5	1,225	.016	5.0	2.2	Vitrified.....	Chocolate
7	1,250	.00	4.9	2.34	Vitrified.....	Chocolate

Yellow clay. Lime pebbles not numerous. Suitable for face brick and tile if lime pebbles can be controlled. Burned by M. C. Huck.

The clay was spaded into a small horse car and drawn for 40 feet on a wooden track to the plant. The plant is equipped with:

Roll crusher.
Auger extrusion machine for tile or end cut brick.
Down draft kiln.

The Scofield Tile Company one-half mile west of Scofield on the D. T. & I. railroad in section 28, T. 5 S., R. 8 E., has not run since 1921. Demand was good but the company went bankrupt, reported due to poor management, and is now in the hands of Mr. McCormick, Carleton, Michigan, as receiver. The company owns 40 acres of clay similar to that at Maybee, and has dug over about two to three acres in four or five years operation. The clay was spaded into small horse cars and drawn to the plant where the cars were lifted on a steam hoist and dumped into a bin. The clay was passed through a roll crusher and was extruded in

a Brewer Tile Machine with automatic cut off. The tile were dried in a shed and burned in two down draft kilns, one of which is a complete wreck. The plant employed five to six men and produced 4,000 to 5,000 three inch tile a day. The high wages paid by the railroad and the large amount of road building made it difficult to obtain help. Mr. Fred Gorrick reports that there is not much hope of the plant operating again.

The clay is good material for brick or tile for the upper five or six feet. At greater depths lime pebbles are found and the lime content increases, giving a narrow burning range. Sample 1039 is of the yellow clay in the upper six feet of the pit.

Burning Test

Sample No. 1039. Field Sheet No. 1045.
Section No. 28, T. 5 S., R. 8 E.
Plasticity 0.225 gm. water per gm. clay.
Average linear drying shrinkage 6 per cent.
Average tensile strength about 138 lbs. per sq. in.
Apparent Sp. Gr. of air dried sample 2.27.

Cone No.	Temp. °C. by Thermo-couple.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.358	2.0%	2.62	Soft burned.....	Salmon
08	952	.329	4.0	2.94	Soft burned.....	Salmon
06	1,015	.311	4.9	2.83	Soft burned.....	Salmon
04	1,070	.284	2.0	2.90	Soft burned.....	Red
02	1,110	.248	2.9	2.54	Hard burned....	Red brown
1	1,150	Cracked	.....	.....	Hard burned....	Chocolate
3	1,195	.030	3.1	2.20	Vitrified.....	Chocolate
5	1,225	.038	3.9	2.20	Vitrified.....	Chocolate
7	1,250	.026	2.0	1.98	Vitrified.....	Chocolate

Yellow clay—suitable for face brick and tile.
No lime pebbles. Burned by M. C. Huck.

John Klein formerly made tile at Carleton from the upper yellow clay similar to that at South Rockwood.

At South Rockwood there are two plants, both using the upper 2-2½ feet of yellow clay, as at greater depths the clay contains a layer of limestone pebbles in blue clay which is very similar to the blue clay underlying the yellow clay in the western part of the county. This blue clay probably underlies the entire county, since wherever the yellow clay was drilled with the sampling auger the blue clay was found underneath.

Mr. Roberts owns a tile plant in NW¼ Section 21, T. 5 S., R. 10 E. He is not familiar with the business and is not very successful, having done nothing since 1920. The plant is of the usual type including pugmill, rolls, auger machine, closed drying sheds, and two 18 foot round, downdraft kilns.

A short distance east of the Roberts plant, Ritter operates a small flower pot pottery, using the upper part of the clay. The clay is pre-

pared in a pug mill and roll crusher, and molded by two spindles for jolly pressing the flower pots. These presses can turn out as many as 10 pots a minute. The pots are dried in a closed shed and burned in a small rectangular down draft kiln. Ritter and his three sons operate the plant. Sample 71 was taken from the upper two feet of clay as used in the Ritter pottery. It is good clay with a wide burning range of over 10 cones.

Burning Test

Sample No. 71. Field Sheet No. 71.
NW¼ Section 21, T. 5 S., R. 10 E.
Plasticity .334 gm. water per gm. clay.
Average linear drying shrinkage 16.0 per cent.
Average tensile strength about 151 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.281	0.0 %	1.83	Soft burned.....	Salmon
08	990	.252	1.4	1.90	Hard burned....	Salmon
06	1,030	.209	2.1	1.95	Hard burned....	Red
04	1,070	.139	4.6	2.10	Hard burned....	Red
02	1,110	.053	7.5	2.29	Hard burned....	Dark red
1	1,150	.017	6.3	2.24	Vitrified.....	Dark red
3	1,190	.016	4.6	2.11	Vitrified.....	Chocolate
5	1,230	.043	0.5	1.84	Vitrified.....	Chocolate
7	1,270	.291	−3.8	1.66	Overburned.....	Chocolate

Molded easily. Face brick, tile, possibly vitrified ware or pottery.
Burned by H. W. Jackman.

Sample 1052 was taken from the upper stratum of red clay overlying the blue clay (sample 1051) being stripped off the silica rock in the quarry of the Rockwood Silica Co. The clay at this place is poor material.

Burning Test

Sample No. 1052. Field Sheet.
Section 15, T. 5 S., R. 10 E. Red clay from Rockwood.
Plasticity .294 gm. water per gm. clay.
Average linear drying shrinkage 9 per cent.
Average tensile strength about 84 lbs. per sq. in.
Average apparent Sp. Gr. (dry) 2.71.

Cone No.	Thermo-couple Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	905	.397	3.2 %	3.14	Soft burned.....	Salmon
08	945	.339	2.9	2.85	Soft burned.....	Salmon
06	995	.345	2.0	2.76	Hard burned....	Salmon
04	1,045	.258	3.8	2.71	Hard burned....	Salmon
02	1,090	.120	5.0	2.61	Hard burned....	Dark salmon
1	1,130	.018	9.3	2.32	Vitrified.....	Brown
3	1,170	.057	3.5	2.08	Overburned.....	Brown
5	1,210	.150	−23.0	1.33	Overburned.....	Dark brown
7	1,255	....	....	....	Melted	

Red clay. Easy to mold. Containing some lime pebbles.
Burned by M. C. Huck.

Burning Test

Sample No. 1051. Field Sheet.
Section 15, T. 5 S., R. 10 E. Blue clay from Rockwood.
Plasticity .242 gm. water per gm. clay.
Average linear drying shrinkage 6.6 per cent.
Average tensile strength about 96 lbs. per sq. in.
Average apparent Sp. Gr. (dry) 2.85.

Cone No.	Thermo-couple Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	905	.365	1.9	2.87	Soft burned.....	Salmon
08	945	Lime pop	...	....	Soft burned.....	Salmon
06	995	.393	−0.4	2.96	Soft burned.....	Pinkish white
04	1,045	.391	−0.4	2.84	Soft burned.....	Pinkish white
02	1,090	.299	0.0	2.54	Soft burned.....	Pinkish white
1	1,130	Lime pop	...	....	Hard burned....	Olive gray
3	1,170	.151	+4.0	2.48	Hard burned....	Olive gray
5	1,210	Lime pop	...	....	Vitrified.....	Olive green
7	1,255	....	...	....	Melted	

Blue clay. Easily molded. Contains numerous lime pebbles.
Burned by M. C. Huck.

The yellow red clay was formerly worked at other places in the county. Gerard Rhu formerly made brick or tile near Strasburg. There is the wreck of an old brick and tile yard five miles south and one and one-fourth miles east of Petersburg in SW¼ section 35, T. 7 N., R. 6 E. Here the product shows evidence of lime pebbles in the form of lime pops. The remains of the following equipment are still evident:

Boiler.
Pug mill.
Auger machine.
Down draft kiln.

MONTMORENCY COUNTY

Although Montmorency County is underlain by the Coldwater shale, there is so much glacial drift covering this formation that the surface glacial clays only can be considered in discussing the clay resources. The clay generally is red but burns to a light color due to its high lime content.

Sample 165 taken just east of Hillman in Section 24, T. 31 N., R. 4 E., is generally typical of the smooth red clay in this district. The clay (sample 164) on the north side of Hunter's Creek is 15 feet or more in thickness and generally covered by sand or gravel. Through sections 34, 27, 35, 26 of T. 32 N., R. 4 E., it runs up to 30 feet deep, becoming stony in sections 25 and 36, and running to sand toward the east.

Burning Test

Sample No. 165. Field Sheet No. 185.
Section 26, T. 30 N., R. 3 E.
Plasticity .316 gm. water per gm. clay.
Average linear drying shrinkage 13.5 per cent.
Average tensile strength about 210 lbs. per sq. in.
Apparent Sp. Gr. 2.52.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp Gr.	Hardness.	Color.
010	950	.359	1.0 %	2.62	Soft burned.....	Light red
08	990	.349	1.0	2.57	Soft burned.....	Salmon
06	1,030	.342	2.0	2.75	Soft burned.....	Salmon
04	1,070	.345	2.1	2.65	Soft burned.....	Salmon
02	1,110	.161	6.6	2.41	Hard burned....	Salmon brown
1	1,150	.076	9.4	2.39	Hard burned....	Olive brown
3	1,190	.039	11.2	2.40	Vitrified.....	Olive
5	1,230	....	....	....	Viscous	

Light red clay. Molded easily. Fairly good material for common brick and tile and might be used for some pottery purposes.

Burned by H. W. Jackman.

In the southern part of the county there is some red burning clay. Samples 190 and 191 were taken by F. F. Stutesman from the southern edge of Montmorency County, section 34, T. 29 N., R. 3 E. According to Mr. Stutesman the samples were taken at different depths from a deposit of clay covered by a veneer of sand six inches to two feet thick.

Sample No. 190.
Section 34, T. 29 N., R. 3 E.

Cone No.	Cone Temp. °C.	Porosity.	Apparent Sp. Gr.	Linear Shrinkage.	Hardness.	Color.
010	950	25.28 %	2.43	...	Hard burned....	Light brown
08	990	26.55	2.51	...	Hard burned....	Red brown
06	1,030	28.57	2.68	0.5 %	.....	Red brown
04	1,070	18.95	2.48	3.5	.....	Red brown
02	1,110	12.42	2.42	...	Vitrified.....	Red brown
1	1,150	19.57	1.69	−6.3	Vitrified.....	Red brown
2	1,170	6.24	2.75	...	.....	Red brown
5	1,230	.....	....	...	Vitrified.....	Brown

Plasticity poor; material crumbled and could not be handled as clay.

Might be used for soft mud brick. Has peculiar colloidal properties not plastic.

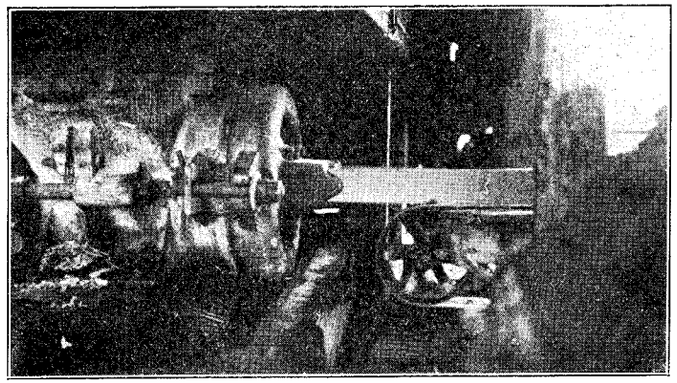

Plate XXXIX, Figure 1.—Clay bars issuing from die of auger machine, Muskegon Brick Co.

Plate XXXIX, Figure 2.—Clay bar cut into bricks (end cut) on take-off belt, Muskegon Brick Co.

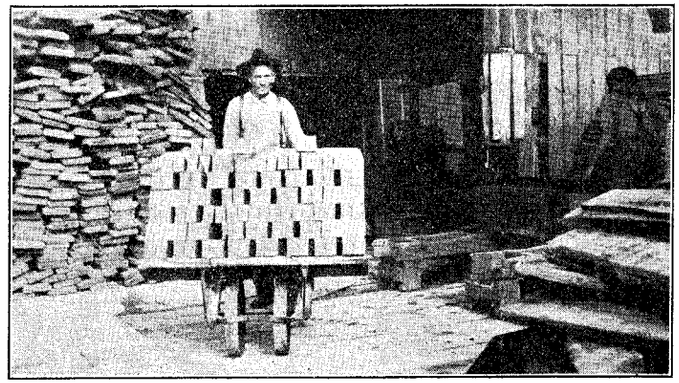

Plate XXXIX, Figure 3.—Loaded pallet of green brick on two-wheeled truck, Muskegon Brick Co.

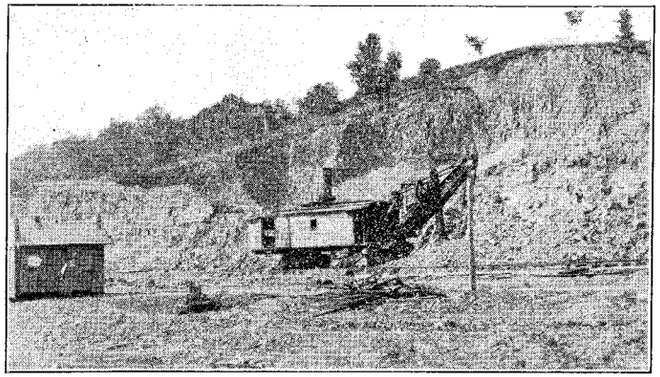

Plate XL, Figure 1.—Ellsworth quarry (Upper "Antrim" or Bedford shale), showing yellow shale and main body of blue shale.

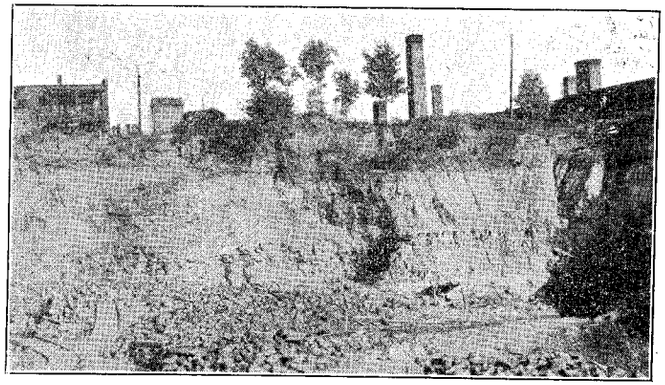

Plate XL, Figure 2.—Coal measures shale at Corunna. Shale is loaded on cars which coast down into the mine and are then drawn up into the plant by a hoist.

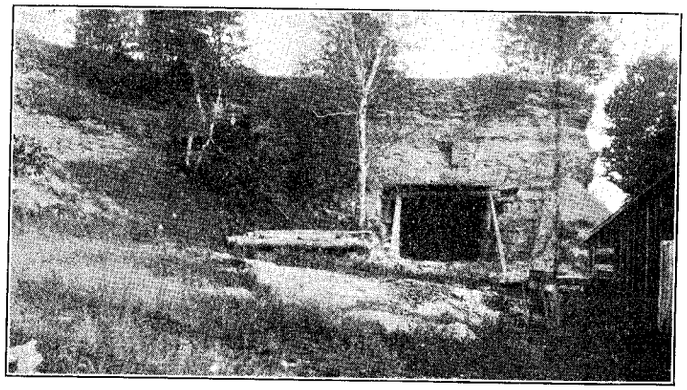

Plate XL, Figure 3.—Quarry in upper blue shale. Stonington peninsula, Delta county.

Sample No. 191.
Section 34, T. 29 N., R. 3 E.

Cone No.	Cone Temp. °C.	Porosity.	Apparent Sp. Gr.	Linear Shrinkage.	Hardness.	Color.
08	950	.....	....	.....	Soft burned.....	Cream
06	990	48.60 %	2.38	−5.65	Soft burned.....	Cream
04	1,030	55.08	2.96	−1.70	Soft burned.....	Cream
1	1,150	.....	2.86	+9.60	Soft burned.....	Cream
4	1,210	.....	....	.....	Soft burned.....	Cream
5	1,230	50.60	2.68	−2.0	Soft burned.....	Cream
8	1,290	50.98	2.80	−0.2	Soft burned.....	Cream
9	1,310	.....	....	−2.3	Soft burned.....	Cream

Plasticity poor,—like sand; material crumbled if handled.
Similar to 190 in properties except color.

MUSKEGON COUNTY

About 100 acres along the southeast side of White Lake near Whitehall, T. 12 N., R 17 W., consist of one to four feet of red gravelly clay burning to a red brick, underlain by about 40 feet of smooth blue clay containing some lime pebbles and burning to a very light brick. This lower blue clay is typical of similar deposits in this district. The Ruggles clay pit is 200 yards north of the road just nqrtheast of Whitehall in sections 22 and 28, T. 12 N., R. 17 W. This clay was used to make brick and drain tile for some years previous to 1907. Wood fuel has become scarce and the town has grown so that it now covers most of the deposit. Mr. Charles Ruggles reports that they have no intention of working the deposit. Sample 42 was taken from the old Ruggles pit and has practically the same burning properties as sample 1021, Oceana County.

Burning Test

Sample 42. Field Sheet No. 42.
Sections No. 22, 28, T. 12 N., R. 17 W.
Plasticity .261 gm. water per gm. clay.
Average linear drying shrinkage 8.3 per cent.
Average tensile strength about 130 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.369	2.1 %	1.64	Soft burned.....	Salmon
08	990	.384	2.4	1.63	Soft burned.....	Salmon
06	1,030	.431	1.8	1.60	Soft burned.....	Cream
04	1,070	.436	2.0	1.60	Soft burned.....	Cream
02	1,110	.435	2.0	1.61	Soft burned.....	Cream
1	1,150	.393	4.1	1.70	Soft burned.....	Cream
3	1,190	.120	13.4	2.32	Hard burned.....	Olive
5	1,230	.033	17.2	2.68	Vitrified.....	Olive
7	1,270	.043	16.7	2.64	Vitrified.....	Olive
9	1,310	....	....	....	Melted	

Light gray-blue clay; molded easily. Can be used for cream brick and tile. Burned by H. W. Jackman.

West of the Pere Marquette Railroad in the western part of Section 16, T. 12 N., R. 17 W., the red clay is more pebbly.

The Muskegon Brick Company has its plant at Holton about one mile northeast of town on the P. M. R. R. in the SE¼ of Section 14, T. 12 N., R. 15 W. The clay deposit covers about 50 acres to a depth of 12 to 14 feet. The upper 12-18 inches of the deposit burn red (sample 44). Under this the main body of clay is composed of about six feet of varying red and blue clay, and about six feet of blue clay. Both of these lower layers, (sample 43) burn to a nearly white brick. Some sand pockets are found in the deposit. This sand is mixed with the clay at the pit, to temper the clay and reduce its shrinkage. A few lime pebbles are occasionally encountered, but not enough to cause trouble or loss. The following tests of the main clay bed indicate that the clay is good material for brick or tile.

Burning Test

Sample No. 43. Field Sheet No. 43.
Section 14, T. 12 N., R. 15 W., Muskegon Brick Co., Holton.
Plasticity .269 gm. water per gm. clay.
Average linear drying shrinkage 8.1 per cent.
Average tensile strength about 130 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
06	1,030	.468	0.9 %	Soft burned.....	Cream
04	1,070	.462	0.9	Soft burned.....	Cream
02	1,110	.390	1.2	Soft burned.....	Cream
1	1,150	.390	3.7	Hard burned.....	Light olive
3	1,190	.390	3.8	Hard burned.....	Light olive
5	1,230	.315	8.6	Hard burned.....	Olive
7	1,270	.154	13.3	Hard burned.....	Olive
9	1,310	....	....	Melted	

Molded easily. Suitable for brick and tile.
Burned by H. W. Jackman.

Chemical Analysis

Sample No. 43. Field Report Sheet 43.
Lower blue clay in deposit Section 14, T. 12 N., R. 15 W.

			Average
Loss on ignition..	19.32%	19.68%	19.50%
SiO_2	38.70	39.68	39.19
Fe_2O_3	3.54	3.40	3.47
Al_2O_3	20.90	20.92	20.91
CaO	14.49	14.77	14.63
MgO	1.31	.71	1.01
Na_2O K_2O	....	....	2.13
Analyzed by H. W. Jackman.			100.84%

The plant is operated and one-third owned by Mr. Van der Heyden of Holton. Messrs. Buck and Mullen of Muskegon Building Materials Company each have one-third interest.

The clay is dug by means of a scoop drawn by a kerosene tractor. The tractor draws the two wheeled scoop up the inclined face of the bank, circles around, and draws the lowered scoop down the face of the pit. The loaded scoop is then drawn up on a loading platform. The clay is dumped directly into a wagon which carries the clay to the plant.

The equipment is driven by steam power and consists of a horizontal pug mill, a vertical pug mill mounted on an auger machine extruding through a twin die. The bricks are air dried under canvas for ten days, and burned in coal fired scove kilns using forced draft. The product is a first class cream brick, sometimes stained red by the action of the flames. The capacity of the plant is limited to about 20,000 brick a day by the drying yard. The annual production is about 2,000,000 bricks.

NEWAYGO COUNTY

Newaygo County is very similar to Lake, Osceola, and Mecosta counties. The surface is almost entirely moraine and outwash plains. In the northeast corner of the county in T. 16 N., R. 11 W., there is a sandy stony red clay, underlain by a clean sand. To the southwest, in T. 14 N., R. 13 W., east of Diamond Lake, (or Ramona) the same stony red clay of the moraine is underlain by a dense plastic blue clay. On the farm just southeast of the four corners, at the center of the line common to sections 11 and 12, in the NE¼ section 11, T. 14 N., R. 13 W., there is 12 feet of sandy red clay over 50 feet of dense plastic blue clay.

The sandy clay found in the glacial outwash in the southwest corner of Newaygo, Section 25, T. 12 N., R. 13 W., was formerly used by a brick yard making soft mud brick. This old yard was located on the P. M. R. R. at the southern limits of Newaygo.

About one mile west of the center of Grant just north of the road in section 14, T. 11 N., R. 13 W., are the remains of the Grant Tile Company. The steam power plant is a complete wreck. The auger machine has been run occasionally by a tractor, to extrude drain tile. The drying sheds are in ruins and in 1922 only one of the two down draft kilns appeared at all usable. The land near Grant is all low and marshy and appears to be largely clay, probably till clay deposited under the ice sheet. Around the plant of the Grant Tile Company the clay runs red to blue and about 15 feet deep. Sample 30 was taken from the stock pile of the plant. The following test indicates that the clay is good for brick or

tile and could be used to make a hard red brick salable as face brick. The clay has a burning range of almost six cones and develops a good red color.

Burning Test

Sample No. 30. Field Sheet No. 29.
SE¼ Section 14, T. 11 N., R. 13 W.
Plasticity .313 gm. water per gm. clay.
Average linear drying shrinkage 13.9 per cent.
Average tensile strength about 200 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	950	.319	0.2 %	Soft burned.....	Salmon
08	990	.293	0.2	Soft burned.....	Salmon
06	1,030	.293	0.5	Soft burned.....	Salmon
04	1,070	.226	2.7	Hard burned.....	Light red
02	1,110	.096	6.9	Hard burned.....	Red brown
1	1,150	.034	7.0	Hard burned.....	Red brown
3	1,190	.029	1.4	Vitrified.....	Chocolate
5	1,230	.032	−3.9	Overburned.....	Chocolate
7	1,270	....	...	Melted	

Molded easily. Begins to fail at cone 3. The vitrified bricks are brittle and easily broken. Suitable for brick and tile or possibly for a red brown face brick.

Burned by H. W. Jackman.

The Newaygo Portland Cement Company was organized on May 24, 1899, with a capital of $2,000,000. The factory was built in 1900 and 1901 on the present site to use the water power developed by the Muskegon River and local marl and clay. The local morainic clay was too sandy and stony, and the marl proved unsatisfactory. At present shale is obtained from Ellsworth, Charlevoix County, and limestone from Petoskey. The wet process is used. Recently waste heat boilers have been added to the kilns.

Originally clay was obtained along the Muskegon River opposite the plant. This clay is reported as follows:*

Silica (SiO_2)	55.84%
Iron Oxide (Fe_2O_3)	3.02
Alumina (Al_2O_3)	8.90
Lime (CaO)	9.98
Magnesia (MgO)	5.16
Ignition Loss	13.68

This clay is not satisfactory for cement and was superseded by clay found with the gypsum at Grand Rapids (in the Grand Rapids Series), and later by the shale from Ellsworth, Antrim County.

*Mich. Geol. Survey VIII, Pt. III, p. 241 (1900).

The plant is electrically operated by power obtained from two 500 H. P. generators driven by eight reaction water wheels under a 15 foot head. Recently waste heat boilers have been installed to supply additional power. The slurry is agitated by air and lifted by compressed air in blow cases.

The limestone is obtained from Petoskey, crushed, mixed with shale from Ellsworth, and ground wet in Smidth Kominuters and Tube mills. The slurry then passes through the usual correction tanks, and is fed automatically to the kilns. The burned clinker is conveyed to the dry grinding building and finely ground in Griffin mills. The ground clinker is conveyed to the cement warehouse.

The coal is crushed, dried, ground in Griffin mills and screw-conveyed to bins over the kiln burners.

The following analysis of the shale obtained from Ellsworth was supplied by Mr. Miller, Chief Chemist:

Ignition loss	14.00%
Silica (SiO_2)	47.50
Alumina (Al_2O_3)	16.60
Iron (Fe_2O_3)	6.10
Lime (CaO)	6.70
Magnesia (MgO)	6.60

OAKLAND COUNTY

There is a deposit of smooth, blue, heavy plastic clay covering about 40 to 60 acres to a depth of 50 feet or more, about two miles east of Franklin in section 36, T. 2 N., R. 9 E. The clay outcrops on the north side of the river which has cut a 50 foot ravine through part of the deposit. In some places the blue clay is overlain by a few feet of red clay.

Many years ago this clay was worked up into hand molded soft mud bricks after being tempered by oxen in a tread mill. The Bigelow Clay Products Company is working the deposit and produces building tile sold chiefly in Detroit and suburban towns. Transportation is by truck 20 miles over concrete roads to Detroit, or the many improved gravel roads in the suburban district.

The clay is rather easy to mold but it has a rather narrow burning range so that it must be fired carefully. But in most places it is free from lime pebbles and generally is more satisfactory than the clay used by the State plant at Onondaga. Samples 1 and 2 were taken from the upper and lower parts of the deposit and were mixed for testing.

The short burning range and the occasional zones of lime pebbles have given much trouble. By careful preparation, drying, and burning of the clay good building tile is produced without excessive dryer and kiln losses.

Burning Test

Sample 1 and 2. Field Report Sheet No. 8.
30 ft. section through bank. Sec. 36, T. 2 N., R. 9 E.
Water of plasticity 0.278 gm. water per gm. clay.
Average linear drying shrinkage 7.37 per cent.
Samples held at 750°C. for 4 hours.
Tensile strength of air dried samples about 120 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Fired Linear Shrinkage.	Color.	Hardness.
010	950	.370	1.5 %	Salmon.....	Soft burned
08	990	.365	2.0	Salmon.....	Soft burned
06	1,030	.375	2.3	Buff.....	Soft burned
04	1,070	.293	4.4	Cream brown.....	Soft burned
02	1,110	.265	4.6	Light brown.....	Hard burned
1	1,150	.120	11.7	Brown.....	Vitrified
3	1,190	Cracked	....	Dark brown.....	Vitrified
5	1,230	Melted	....	Yellow	

Color air dried brick,—brownish gray.
Worked up fairly well.
Analysis by H. W. Jackman.

Chemical Analysis

Sample No. 1 & 2. Field Sheet No. 8.
30 ft. section through bank, Sec. 36, T. 2 N., R. 9 E.

Loss on ignition	13.69%
SiO_2	44.80
Al_2O_3	20.52
Fe_2O_3	3.89
CaO	13.10
MgO	1.85
Na_2O K_2O	2.15

In 1924 the Bigelow Clay Products Co. built a fine modern plant using all electric power and equipped to make building tile from this clay. The clay is dug by a large electric shovel, dumped into skip cars which are drawn up into the plant by a cable in the usual manner. The clay is then dumped into a large storage bin over the clay feeder and roll crushers. After passing through the double rolls the clay is conveyed to a pug mill on a raised platform from which it passes into the auger extrusion machine. The tile are cut by an automatic cut off and stacked on the drier cars. The drier is ten tunnel continuous drier, heated

entirely by waste heat drawn from the cooling kilns. The tile are burned in seven oil fired, down draft kilns 32 feet in diameter. Burning takes about 70 hours and the kilns can handle only about one-half the daily capacity of the auger machine. Forced draft is now being used to aid in water smoking and another kiln is under construction. When completed this unit of the plant will have a daily capacity of about 30,000 twelve inch tile.

This is the only plant making building tile exclusively in the State. The product is a smooth uniform tile and is easily sold in the Detroit district. The narrow burning range of the clay was a serious difficulty which has now been completely overcome so that the kiln scrap is now well under three per cent. This is made possible by careful burning, controlled by two thermocouples in each kiln, one in the crown and the other in the side wall near the floor, and checked by six sets of cones, placed in strategic points in the kiln. This company has mastered a difficult proposition.

The Birmingham Brick and Tile Company formerly worked a deposit just south of Birmingham in Section 36, T. 2 N., R. 10 E. The property is now owned by Ed. Daniels who was one of the former operators. He reports that the clay is hopeless, full of lime pebbles, and found only in small pockets. There is no extensive bank or uniform deposit. Daniels operated the plant after the original company abandoned it. Then the local bank aided by an experienced man from outside the state operated it for two years, but apparently without success.

OCEANA COUNTY

In the northwestern part of Oceana County, just east of Pentwater, T. 16 N., R. 18 W., there is a strip of blue clay in the lowland, about one-half mile wide and about four to five miles long, from north to south. About 1895 this clay was used to make a light colored brick used in local construction.

Some lake deposited clay is found in T. 15 N., R. 18 W., in the district just north of Silver Lake. This clay is light blue in color, dense and plastic, and seems very similar to the clay reported just east of Pentwater. The clay contains lime and is probably suitable for common brick only. Farther south in the Stony Lake district near Benona (T. 13 & 14 N., R. 18 W.) there is another area of plastic dense blue clay containing lime pebbles, gravel, and small boulders.

East of these deposits the surface clay is generally in moraines with a few small boulder clay plains. The clay is usually red, sandy, and stony, and underlain by blue clay or sand which is frequently wet.

There were formerly three different brick yards at various times near Hart, Section 17, T. 15 N., R. 17 W. In the northeast corner of Hart in Section 9, blue clay containing lime pebbles was used about 1880 to make light buff brick. The brick were of fair quality and were used locally. About one-half mile south of Hart, in section 21, H. Nort formerly made brick from similar boulder clay. There was also an old yard along the river in the northwest corner of the town in section 8.

South of Shelby in section 24, T. 14 N., R. 18 W., Clint Morningston about 1905 ran a brick yard on the Hill place. Throughout this district the clay is generally red on the surface and blue below. The clay is about 40 feet deep and underlain by water bearing sand or gravel. The clay contains lime, and frequently lime pebbles are found, which may have been one of the reasons for abandoning the brick yard. The following test shows the clay to be of little value:

Burning Test

Sample No. 1021. Field Sheet No. 1026.
Section No. 19, T. 14 N., R. 17 W. and section 24 T. 14 N., R. 18 W.
Plasticity .267 gm. water per gm. clay.
Average linear drying shrinkage 8.8 per cent.
Average tensile strength about 163 lbs. per sq. in.
Apparent sp. gr. dry 2.47.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.430	1.1%	2.72	Soft burned.....	Salmon
08	990	.430	+0.2	2.64	Soft burned.....	Cream
06	1,030	.446	−0.2	2.68	Soft burned.....	Cream
04	1,070	.458	+0.2	2.80	Soft burned.....	Cream
02	1,110	.448	1.7	2.81	Soft burned.....	Cream
1	1,150	.426	2.1	2.79	Soft burned.....	Cream
3	1,190	.360	7.0	2.86	Hard burned....	Cream olive
5	1,230	.130	13.2	2.67	Hard burned....	Light olive
7	1,270	.044	16.0	2.58	Vitrified.....	Olive
9	1,310	....	....	....	Viscous	

Rey clay; molded easily. Suitable for making cream colored common brick or tile.

Burned by H. W. Jackman.

OGEMAW COUNTY

A sample of boulder clay taken from the eastern part of the county, Section 13, T. 22 N., R. 3 E., seems to be suitable for common brick and tile where sufficiently free from stone and lime pebbles. The clay runs about 10 to 40 feet thick and in this place contains a layer of quicksand about six feet below the surface.

Burning Test

Sample No. 167. Field Sheet No. 187.
Section 13, T. 22 N., R. 3 E.
Plasticity .187 gm. water per gm. clay.
Average linear drying shrinkage 5.7 per cent.
Average tensile strength about 160 lbs. per sq. in.
Apparent Sp. Gr. dry 2.62.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.372	1.2%	2.77	Soft burned.....	Salmon
08	990	.387	0.1	2.77	Soft burned.....	Cream salmon
06	1,030	.410	+0.3	2.93	Soft burned.....	Cream salmon
04	1,070	.371	−0.2	2.68	Soft burned.....	Cream
02	1,110	.363	−1.3	2.60	Soft burned.....	Cream
1	1,150	.296	+3.5	2.69	Hard burned....	Light olive
3	1,190	.308	3.6	2.78	Hard burned....	Light olive
5	1,230	.139	8.0	2.54	Hard burned....	Olive
7	1,270	.113	9.8	2.60	Vitrified.....	Olive
9	1,310	....	...	....	Viscous	

Slightly grainy, reddish brown clay containing lime pebbles. Molded easily.

Burned by H. W. Jackman.

The Lupton Portland Cement Company, incorporated under the laws of New Jersey in January, 1901, for one and a quarter million dollars ($1,250,000) began construction in April, 1901, on a cement plant in Lupton. The company proposed to build a plant of 1,200 barrels daily capacity and to use the boulder clay and marl beds found near Lupton. The following analysis of the clay reported near Lupton was made for this company by Lathbury and Spackman of Philadelphia, Penn.*

Loss on ignition	7.58%
Silica (SiO_2)	56.09
Alumina+Iron Oxide (Al_2O_3+Fe_2O_3)	28.89
Lime (CaO)	0.00
Magnesia (MgO)	0.58
Sulphur Trioxide (SO_3)	0.41
Difference	6.45

The sample must have been taken from the surface and leached free of lime, but even this would seem unable to account for 0.00% of lime

*Mich. Geo. Survey, Vol. VIII, Pt. III, p. 299.

(CaO) in any boulder clay in this part of Michigan. If this analysis were representative of any clay near Lupton, which is probably not true, Lupton should be able to supply the district with excellent building brick and tile, if not even better grades of ceramic ware.

OSCEOLA COUNTY

A brick yard two and one-half miles south of Marion ran for six months during 1908. The brick were of poor quality and crumbled. The clay is as much as 50 feet in thickness but it is generally poor material and very variable in quality, as is most of the glacial clay.

Sample 32 was taken from this same morainic red clay in sections 25 and 26, T. 20 N., R. 8 W., about four miles west of Marion on the M. & G. Railroad and six miles north of Avondale. Here the clay is 30 to 40 feet deep and is covered by 20 inches of sand in places. The following burning test indicates that this clay would make good brick and tile and possibly brown face brick if not spoiled by lime pebbles.

Burning Test

Sample No. 32. Field Sheet No. 32.
Sections 25 and 26, T. 20 N., R. 8 W.
Plasticity .255 gm. water per gm. clay.
Average linear drying shrinkage 10.3 per cent.
Average tensile strength about 220 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Hardness.	Color.
010	950	.302	−0.7 %	Soft burned.....	Light red
08	990	.316	−1.1	Soft burned.....	Light red
06	1,030	.322	0.4	Soft burned.....	Light red
04	1,070	.279	0.7	Hard burned.....	Red brown
02	1,110	.196	3.6	Hard burned.....	Dark brown
1	1,150	.168	4.4	Hard burned.....	Dark brown
3	1,190	.045	4.3	Vitrified.....	Chocolate
5	1,230	....	...	Melted	

Molded fairly easily; somewhat grainy. Lime pebbles.
Burned by H. W. Jackman.

About 1895 the clay in the moraine in the northwest corner of LeRoy on the G. R. & I. Railroad was used for making brick. The clay is red brown in color and covers about 40 acres. Brick made from this clay were used in building the school, church, and some homes in the town, and seem to be good brick. The following burning test indicates that this clay is fairly good material for brick or tile.

Burning Test

Sample No. 1020. Field Sheet No. 1024.
Section 13, T. 19 N., R. 10 W., LeRoy.
Plasticity .273 gm. water per gm. clay.
Average linear drying shrinkage 9.7 per cent.
Average tensile strength about 226 lbs. per sq. in.
Apparent sp. gr. dry 2.54.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.360	+0.8 %	2.72	Soft burned.....	Salmon
08	990	.346	−0.4	2.56	Soft burned.....	Salmon
06	1,030	.354	+0.2	2.65	Soft burned.....	Faded salmon
04	1,070	.329	0.7	2.57	Soft burned.....	Faded salmon
02	1,110	.225	4.2	2.43	Hard burned....	Salmon brown
1	1,150	.076	9.2	2.39	Hard burned....	Purplish brown
3	1,190	.031	5.5	2.05	Vitrified.....	Olive
5	1,230	....	...	....	Viscous	

Brownish red clay containing some lime lumps. Molded easily.
Burned by H. W. Jackman.

OSCODA COUNTY.

Through the central part of the county there is a crescent shaped area running from south of Red Oak north to Fairview, that is largely red boulder clay from 8 to 40 feet thick containing some pebbles and stone. In the southern part of this area the clay is covered by sand and is blue in color. Sample No. 162 was taken from this district in section 27, T. 27 N., R. 1 E. Sample No. 163 was taken from section 25, T. 27 N., R. 2 E.

Burning Test.

Sample No. 162. Field Sheet No. 183.
Sections 27-26, T. 27 N., R. 1 E.
Plasticity .298 gm. water per gm. clay.
Average linear drying shrinkage 10.0 per cent
Average tensile drying strength about 165 lbs. per sq. in.
Apparent Sp. Gr. Dry 2.58.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.354	−0.3 %	2.42	Soft burned.....	Salmon
08	990	.396	+2.6	2.69	Soft burned.....	Cream salmon
06	1,030	.390	2.1	2.73	Soft burned.....	Cream
04	1,070	.397	2.4	2.75	Soft burned.....	Cream
02	1,110	.388	2.6	2.78	Soft burned.....	Cream
1	1,150	.235	9.5	2.76	Hard burned....	Light olive
3	1,190	.117	13.5	2.75	Vitrified.....	Olive
5	1,230	....	...	....	Viscous	

Blue clay. Molded easily.
Burned by H. W. Jackman.

Burning Test.

Sample No. 163. Field Sheet No. 184.
Section 25, T. 27 N., R. 2 E.
Plasticity 0.289 gm. water per gm. clay.
Average linear drying shrinkage 8.8 per cent.
Average tensile strength about 194 lbs. per sq. in.
Apparent Sp. Gr. of Air Dried Sample, 2.55.

Cone No.	Thermo-couple Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.372	2.1 %	2.75	Soft burned.....	Salmon pink
08	952	.388	2.75	2.82	Soft burned.....	Salmon pink
06	1,015	.387	3.1	2.82	Soft burned.....	Salmon pink
04	1,070	.370	3.9	2.90	Soft burned.....	Salmon red
02	1,110	.260	5.2	2.94	Hard burned....	Reddish brown
1	1,150	Cracked	in burning	....	Hard burned....	Brown
3	1,195	.000	9.2	2.31	Vitrified.....	Dark brown
5	1,225	....	....	....	Viscous	

Yellow clay. Comparatively free from pebbles. Easy to mold.
Burned by M. C. Huck.

Morainic clay of the same general properties is found east of Luzerne in section 25, T. 26 N., R. 1 E., and sections 14 and 15, T. 26 N., R. 2 E. All of the clay is underlain by water bearing gravel at about 40 feet below the surface.

OTSEGO COUNTY.

Otsego County is completely covered with boulder clay of varying composition and content of pebbles. About 1899 a Mr. Comstock made brick from some boulder clay found in the moraine about one-half mile north of Gaylord on the Jessup property, section 28, T 31 N., R. 3 W. The clay is at least 25 feet thick at this place and seems to be quite free from stones. The same deposit extends for about 2 or 3 miles northward along both sides of the highway.

Sample No. 1009 taken from this deposit has burning properties very similar to the Antrim shale (sample 96) found on Pine Lake in Charlevoix County. The following burning test indicates that this clay when free from stone is very suitable for brick and tile, and also for face brick:

Burning Test.

Sample No. 1009. Field Sheet No. 1016.
Section 28, T. 31 N., R. 3 W.
Plasticity .214 gm. water per gm. clay.
Average linear drying shrinkage 5.9 per cent.
Average tensile strength about 161 lbs. per sq. in.
Apparent Sp. Gr. dry 2.50.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.316	−0.4 %	2.65	Soft burned.....	Salmon
08	990	.301	−0.8	2.63	Soft burned.....	Salmon
06	1,030	.288	+0.6	2.66	Soft burned.....	Salmon
04	1,070	.247	2.5	2.62	Soft burned.....	Light red
02	1,110	.139	4.8	2.50	Hard burned....	Dark red
1	1,150	.083	5.4	2.39	Vitrified.....	Chocolate red
3	1,190	.050	+5.6	2.30	Vitrified.....	Chocolate
5	1,230	.046	−1.0	1.90	Vitrified.....	Chocolate
7	1,270	.056	−2.3	1.82	Overburned	Chocolate brown
9	1,310	....	...	....	Viscous	

Brown clay; containing a few pebbles (not lime). Molded easily.
Burned by H. W. Jackman.

OTTAWA COUNTY.

The Zeeland Brick Company operated a plant until 1922, about one mile west of Zeeland, on the inturban line between Holland and Grand Rapids. The plant made wire-cut brick from clay in the NE¼ of Section 23, T. 5 N., R. 15 W. The clay ran about 15 feet deep with a stratum of lime pebbles near the top. All the usable clay was exhausted by the end of the season of 1922, when the plant was closed.

PRESQUE ISLE COUNTY.

In the western part of the county four miles south of Onaway, in T. 34 N., R. 2 E., the clay runs 90 feet deep in the northwest corner of section 32 where sample 160 was taken. Two miles north the clay is only 3 to 4 feet thick. In section 20 the red clay is 15 feet thick and is underlain by about 30 feet of blue clay.

In the central part of section 27, T. 35 N., R. 3 E., about 3½ miles north of Millersburg on highway M-10, the clay is found in hills and along the river bank with deposits of yellow sand. This clay seems to be free from pebbles and molds easily. The following burning test shows it to have an extremely narrow burning range, due to a high lime content, so that the clay can be used only for porous soft burned ware, such as common brick and tile. The high lime content is due to the fact that most of this county is underlain at shallow depth by limestone.

Burning Test.

Sample No. 131. Field Sheet No. 141.
Section 27, T. 35 N., R. 3 E.
Plasticity .220 gm. water per gm. clay.
Average linear drying shrinkage 6.5 per cent.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.441	−1.2 %	1.44	Soft burned.....	Flesh
08	990	.472	−2.0	1.40	Soft burned.....	Flesh
06	1,030	.476	−2.2	1.38	Soft burned.....	Cream
04	1,070	.481	−2.2	1.37	Soft burned.....	Cream
02	1,110	.474	−2.6	1.38	Soft burned.....	Cream white
1	1,150	.473	−1.4	1.40	Soft burned.....	Cream white
3	1,190	.457	−0.2	1.46	Soft burned.....	Cream white
5	1,230	.460	+1.2	1.51	Soft burned.....	Cream
7	1,270	.455	+1.9	1.56	Soft burned.....	Cream
9	1,310	.037	14.8	2.31	Vitrified.....	Olive
11	1,350	....	....	....	Melted	

Light red clay. Molded easily.
Burned by H. W. Jackman.
This clay seems similar to samples 128 and 159 of Cheboygan County.

The Bell shale about 50 feet thick extends from Black or Cheboygan Lake east-southeastward through Presque Isle County, through Bell in T. 33 N., R. 8 E., to Rockport in the extreme northeast corner of Alpena County. Sample No. 132 was taken from a ledge of this shale about 3 miles west of Rogers City. At the surface the shale had weathered to a clay, but drill tests showed firm shale at shallow depth. Another exposure of Bell shale occurs in the northern part of section 13, T. 34 N., R. 6 E., but it was not sampled. These deposits of shale are extensive and deserve further investigation especially by the drill.

Burning Test.

Sample No. 132. Bell Shale. Field Sheet No. 142.
Section 30, T. 35 N., R. 5 E.
Plasticity .331 gm. water per gm. clay.
Linear drying shrinkage 9.7 per cent.
Average tensile strength about 70 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Absorption.	Linear Shrinkage.	Hardness.	Color.
010	950	.323	.200	−1.1 %	Soft burned.....	Tan
08	990	.316	.184	+1.1	Soft burned.....	Tan
06	1,030	.268	.144	3.7	Hard burned.....	Light red
04	1,070	.183	.089	7.4	Hard burned.....	Red
02	1,110	.009	.0035	10.0	Vitrified.....	Dark red
1	1,150	.008	.003	8.7	Vitrified.....	Brown
3	1,190	.014	.005	2.8	Vitrified.....	Dark brown
5	1,230	.088	.036	0.9	Vitrified.....	Dark brown
7	1,270	....	....	....	Melted	

Easily molded. Good material for all kinds of building brick, face brick, and tile, and might be used for some pottery purposes.
Burning test by H. W. Jackman.

The burning properties of this sample are very similar to those of sample 95, of the Antrim shale. The Bell "shale" has a narrower burning range than some parts of the Antrim shale, but molds more easily and is free from bituminous material. The Bell shale need not be ground to develop its plasticity and it can be oxidized much easier. Taking everything into consideration certain beds of the Bell shale probably are just as good material for making building brick, tile, and face brick, as the Antrim shale. But the Bell shale cannot be used for vitrified ware because the brick begin to fail almost as soon as they are vitrified and the vitrified product is rather brittle. The Bell shale, however, is known to contain thin partings of limestone and calcareous horizons, but the low lime beds appear to be of considerable thickness. While the presence of thin beds of limestone would be serious in the manufacture of brick and tile, these would not be for use in making Portland cement. The shale is adjacent to very large deposits of exceptionally pure limestone; therefore conditions are favorable for making cement. Shale is also found in the limestone 3¼ miles south of Bell in section 34, T. 33 N., R. 8 E., on the road from Alpena to Bell. Sample No. 134 was taken from a 3-foot vein of soft shale found in the limestone at a depth of 12 to 13 feet when drilling a well in this section. Similar clay or clay shale is also found in creek beds and in the bottom of some sink holes in the limestone in this district at depths of 13 to 40 feet. This clay or shale near Bell postoffice gave the name "Bell" to the lowest member of the Traverse Formation.

ROSCOMMON COUNTY.

Roscommon County is largely sand and gravel with some small clay areas. Just northeast of Roscommon village the Au Sable River cuts through some red-blue clay about 10 to 20 feet thick which contains a few lime pebbles or lumps. This clay burns to light red color and might be used to make brick or tile if the lime pebbles can be handled. About 1903 brick was made from clay very similar to this about one mile north of the town, but the lime pebbles made serious trouble. Sample 1008 was taken from the river bank one-quarter mile from the Michigan Central railroad switch.

Burning Test.

Sample 1008. Field Sheet No. 1015.
Section 6, T. 24 N., R. 2 W.
Plasticity .301 gm. water per gm. clay.
Average linear drying shrinkage 12.3 per cent.
Average tensile strength about 200 lbs. per sq. in.
Apparent Sp. Gr. dry, 2.57.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.284	0.4 %	2.44	Soft burned.....	Light red
08	990	.296	0.9	2.52	Soft burned.....	Salmon
06	1,030	.302	1.1	2.55	Soft burned.....	Salmon
04	1,070	.285	2.1	2.56	Soft burned.....	Light brown
02	1,110	.121	7.8	2.41	Hard burned.....	Brown
1	1,150	.035	9.8	2.36.	Hard burned.....	Dark brown
3	1,190	....	....	....	Viscous	

Brown clay. Few lime pebbles. Molded easily.
Burned by H. W. Jackman.

Another sample of blue clay taken about a mile northwest of the town of Houghton Lake shows more promising burning qualities. The sample was taken from two places about one-quarter mile apart and is probably representative of the upper part of this deposit of clay. The clay runs from 12 to 30 feet deep and is covered by sandy loam which runs thicker to the southwest away from the lake. The upper clay is sandy and red in color, blending into the blue smoother clay below. There are pockets and veins of white sand through the clay which is probably a water deposit, and water bearing yellow sand underneath the blue clay. The deposit is not uniform, is sandy in places, and at a distance from any railroad, but its burning properties indicate that it is a good material for brick and tile.

Burning Test.

Sample No. 89. Field Sheet No. 94.
Section 11, T. 22 N., R. 4 W.
Plasticity .269 gm. water per gm. clay:
Average linear drying shrinkage 11.9 per cent.
Average tensile strength about 180 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.274	0.9 %	1.88	Soft burned.....	Light red
08	990	.270	0.9	1.90	Semi-hard burned.	Light red
06	1,030	.283	1.5	1.92	Hard burned.....	Light red
04	1,070	.268	1.6	1.93	Hard burned.....	Light red
02	1,110	.155	5.0	2.15	Hard burned.....	Chocolate red
1	1,130	.125	4.8	2.14	Vitrified.....	Chocolate red
3	1,170	.043	2.3	2.00	Vitrified.....	Chocolate
5	1,230	....	...	....	Viscous	brown

Molds easily. Somewhat grainy. Suitable for brick and tile.
Burned by H. W. Jackman.

SAGINAW COUNTY

The Coal Measures shales of Saginaw County were investigated by Ries.

Sample 217 (Ries), was taken from the dense brownish shale containing plant stems that was found under the coal at the old shaft of the Standard Mining Company, in section 6, T. 11 N., R. 5 E., just southeast of Saginaw. This shale contained small mica scales but very little grit. When ground to 30 mesh it had the following properties:

Burning Test.

Sample R217. Sec. 6, T. 11 N., R. 5 E.
Water plasticity 20 per cent.
Air shrinkage 4 per cent.
Average tensile strength 60 lbs. per sq. in.
Soluble salts 0.2 per cent.

Cone.	Total Shrinkage.	Burning.	Color.
1.....	10 %	Hard.....	Red
4.....	....	Vitrified	
9.....	....	Viscous	

*Mich. Geol. Survey VIII, Pt. I, pp. 26, 28, 33.

Chemical Analysis.

Silica (SiO_2)	55.3%
Alumina (Al_2O_3)	14.2
Ferris Oxide (Fe_2O_3)	3.62
Lime Carbonate ($CaCO_2$)	0.3
Magnesian Carbonate ($Mg\,CO_3$)	2.61
Alkalies (Na_2O+K_2O)	2.15
Water & Organic (Difference)	21.82

In sinking a new shaft on the same property the following section was penetrated:

90 feet sandy clay.
10 feet fine grained blue clay (R212).
3 feet "Impure Fire Clay."
8 feet shale (Sample R220).
4 feet conglomerate.
20 feet black shale.
Coal.
6 feet "fire clay."

A burning test of the 8-foot shale bed at 103 feet below the surface gave the following results:

Sample (Ries) 220.
Water of plasticity 23 per cent.
Air shrinkage 3 per cent.
Tensile strength 35 lbs. per sq. in.
Soluble salts 0.3 per cent.

Cone.	Total Shrinkage.	Burning.	Color.
05	3 %	.....	Buff
1	5	.....	Red
3	7	Hard	Red
5	9	.....	Deep red
7	...	Vitrified	
9	...	Viscous	

Moderate plasticity.

A sample taken from the shale underlying the coal at the old Pere Marquette shaft No. 1 had the following properties:

Sample (Ries) unnumbered.
Water of plasticity 16 per cent.
Air shrinkage 5 per cent.
Tensile strength 38 to 45 lbs. per sq. in.
Soluble salts 0.4 per cent.

Cone.	Total Shrinkage.	Burning.	Color.
01	6 %	Hard	Deep brownish red
4	11	Vitrified	
7	....	Viscous	

Another sample of the "fire clay" taken from under the coal seam 185 feet below the surface at the old shaft of the J. H. Somers Coal Co., near the M. C. Railroad station had the following properties:

Sample (Ries) unnumbered.
Grinds easily, but slakes slowly.
Water of plasticity 18 per cent.
Dried rapidly, air shrinkage 4 per cent.
Soluble salts 0.35 per cent.

Cone.	Total Shrinkage.	Burned.	Color.
1	7 %	Hard	Buff speckled
5	12	Vitrified	Gray buff
8	....	Viscous	

The "fire clay" underlying the coal 10 miles east of St. Charles, as in the NE¼ Section 23, T. 10 N., R. 4 E., Albee Township, was reported to be very plastic and more easily molded than the samples described above.

These tests of the coal measure shales found in Bay, Saginaw, and Genesee Counties as reported by Ries show conclusively that these shales cannot be called "fire clay". Many of the Michigan Carboniferous shales contain large amounts of bituminous material and are useless as ceramic material. Some of the miscalled "fire clays" have sufficiently wide vitrification ranges to be used for the manufacture of vitrified products and in some cases paving blocks.

The shales found in Bay and Saginaw counties 160 to 200 feet below the surface are relatively inaccessible and probably at best suited for pressed or face brick. It seems more probable that economic factors would favor the development of these shales in the counties south of

Saginaw, where they are found near the surface. In fact the Old Saginaw Clay Manufacturing Company at Saginaw formerly made paving brick from the mixed shales obtained from the quarry at Flushing.

Ninety feet below the surface in section 6, T. 11 N., R. 5 E., a ten-foot bed of blue clay (sample R212) was reported by Ries.

Sample R212.
Fine grained clay 100% through 100 mesh.
Contains some lime pebbles.
Water of plasticity 33 per cent.
Air shrinkage 7 per cent.
Tensile strength 110 lbs. per sq. in.
Soluble salts 0.2 per cent.

Cone.	Total Shrinkage.	Burning.
05	....	Hard
01	18%	Vitrified
3	....	Viscous

Very plastic.

Chemical Analysis.

Silica (SiO_2)	47.75
Alumina (Al_2O_3)	17.60
Ferric Oxide (Fe_2O_3)	9.13
Lime Carbonate ($Ca\,CO_3$	2.6
Magnesium Carbonate ($Mg\,CO_3$)	0.7
Alkalies (Na_2O+K_2O)	2.21
Water and Organic (difference)	22.01

Ries suggests that this clay may be weathered or slaked shale as it lies directly on bed rock.

The surface of Saginaw County is largely lake clay containing some sand and generally troublesome lime pebbles. In section 21, T. 13 N., R. 4 E. the surface clay is 65 feet deep and is underlain by 30 feet of hard pan and 10 feet of sand. Further west in section 24, T. 13 N., R. 3 E., the surface clay is 90 feet thick and underlain by 30 feet of sand and gravel and then 40 feet of sandy lake clay. In section 12, T. 13 N., R. 3 E., the surface clay is 65 feet thick and is underlain by 50 feet of hard pan.

Sample 175 was taken from the surface clay four miles east of Saginaw on State Highway M-31 in NW¼ section 23, T. 12 N., R. 5 E. The clay is mixed red and blue, with a cubic fracture, and is about 40 feet thick. In some places it is covered by as much as three feet of

sand. The sample was taken by trenching and from a small pit in a drainage ditch. The burning test was made of the clay as sampled without screening out pebbles.

Burning Test.

Sample No. 175. Field Sheet No. 195.
Section No. 23, T. 12 N., R. 5 E.
Plasticity 0.204 gm. water per gm. clay.
Average linear drying shrinkage 3.0 per cent.
Average tensile stress about 165 lbs. per sq. in.
Apparent specific gravity air dried sample 2.24.

Cone No.	Temp °C. Thermo-couple.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.404	0.5%	2.61	Soft burned	Salmon
08	952	Lime pop	....	....	Soft burned	Cream white
06	1,015	Lime pop	....	....	Soft burned	Cream white
04	1,070	Lime pop	....	....	Soft burned	Cream white
02	1,110	Lime pop	....	....	Soft burned	Cream
1	1,150	.301	7.0%	2.46	Hard burned	Light tan
3	1,195	Lime pop	....	....	Hard burned	Yellow
5	1,225	.03	16.0	2.6	Vitrified	Olive
7	1,250	Lime pop	....	....	Vitrified	Olive
9	.....	....	....	....	Viscous	

Yellow clay containing lime pebbles, which cause the burned clay to disintegrate when soaked in water.
Burned by M. C. Huck.

Thomas Day operates a soft mud brick yard about ¾ mile southwest of Paines on the Michigan Central railroad in SW¼ section 31, T. 12 N., R. 4 E. The plant employs about 30 men and has a daily capacity of 22,000 brick. The clay is dug by a gasoline power shovel and drawn to the plant which is equipped with a Wellington pug-mill and a six brick soft mud molding machine. The green brick are dried in open air dry sheds and burned in scove kilns.

The clay has an appearance similar to that of the Detroit clays. The upper clay is reddish yellow in color, underlain by about one foot of yellow clay, then 8 to 10 inches of red clay, and by 20 feet or more of fat blue clay. It is generally covered by one to two feet of white sand, and contains some stone in places, but rarely any limestone. Sample 142 was taken from the upper red and yellow clay. Sample 143 is from the lower blue or gray clay which makes up the bulk of the deposit.

Burning Test.

Sample No. 143. Field Sheet No. 154.
Section 31, (SW), T. 12 N., R. 4 E.
Plasticity .276 gm. water per gm. clay.
Average linear drying shrinkage 8.3 per cent.
Average tensile stress about 115 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.416	1.3 %	1.57	Soft burned.....	Salmon
08	990	.439	1.3	1.56	Soft burned.....	Cream
06	1,030	.444	1.4	1.56	Soft burned.....	Cream
04	1,070	.439	1.6	1.56	Soft burned.....	Cream
02	1,110	.425	2.0	1.59	Soft burned.....	Cream
1	1,150	.318	7.4	1.88	Hard burned....	Very light olive
3	1,190	.080	14.7	2.40	Hard burned....	Light olive
5	1,230	.032	16.7	2.56	Vitrified.....	Olive
7	1,270	.022	16.9	2.60	Vitrified.....	Olive
9	1,310	....	....	....	Viscous	

Gray brown clay; molded easily. Suitable for brick or tile.
Burned by H. W. Jackman.

The Miller City Co. operates a drain tile plant on the north side of the Michigan Central railroad about ⅞ mile southwest of Paines in SE¼ section 36, T. 12 N., R. 3 E. The clay (sample 144) is the same as that used by Day on the other side of the railroad. The whole plant is completely enclosed by a three-story barn-like structure. The steam plant, rolls, and tile machine are located on the ground floor adjoining the clay shed. The rest of the area is taken up by two 25-foot down draft intermittent kilns. The two upper floors are used as dry floors, being heated by convection from the kilns. The green tile is elevated to either of the two upper floors surrounding the kilns and dried. The dried tile is loaded into the kilns through holes in the tops of the kilns. The burned tile is unloaded in the usual manner through the door on the ground level.

The Saginaw Clay Products Company makes drain tile and building tile from the same lake clay (sample 143) at a plant ½ mile southwest of Paines on the Michigan Central just east of Day's plant in section 31, T. 12 N., R. 4 E. The plant is equipped with steam power, rolls, a Fate auger machine, 3 track tunnel drier heated by separate fires and three 30-foot down draft intermittent kilns. The plant was not operating in 1922 because of market conditions.

Southeast of Saginaw in section 18, T. 11 N., R. 6 E. the surface lake clay is 60 feet thick and is underlain by 30 feet of hardpan and 15 feet of sand.

A sample of clay (No. 1042) was taken near Burt, about 15 miles south of Saginaw, by J. C. Malone and submitted to the Department of Engineering Research of the University of Michigan. The test resulted as follows:

Burning Test.

Sample 1042. Submitted by J. C. Malone of Burt.
Plasticity .421 gm. water per gm. clay.
Average linear drying shrinkage 15 per cent.
Average tensile strength about 122 lbs. per sq. in.
Average apparent sp. gr. (dry) 2.93.
Held at 425°C. for 7 hours to completely oxidize organic matter.

Cone No.	Thermo-couple Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	905	.436	−1.5 %	2.89	Soft burned.....	Salmon
08	945	.421	−0.8	2.89	Soft burned.....	Salmon
06	995	.384	+1.4	2.79	Hard burned....	Salmon
04	1,045	.376	1.6	2.78	Hard burned....	Salmon red
02	1,090	....	...	....	Hard burned....	Salmon red
1	1,130	.192	2.1	2.64	Hard burned....	Salmon brown
3	1,170	.096	8.5	2.44	Vitrified.....	Chocolate
5	1,210	....	...	....	Starting to fail..	Chocolate
7	1,255	....	...	....	Melted	

Reddish brown clay. Free from lime pebbles and suitable for hard burned red brick or tile. Easily molded.
Burned by M. C. Huck.

ST. CLAIR COUNTY.

St. Clair County is largely covered with Pleistocene lake clay.

The Central Peat Company is located on a peat bed 2½ miles west of Capac on the Grand Trunk Railroad in the SW¼ section 19, T. 7 N., R. 13 E. The peat runs about 6 to 14 feet thick over an area reported to be 1000 acres. Under the peat there is about 8 to 15 inches of a light gray clay (sample 150) which burns to a good color at cone 02.

Burning Test.

Sample No.. 150. Field Sheet No. 167.
SW¼ section 19, T. 7 N., R. 13 E.
Plasticity .207 gm. water per gm. clay.
Average linear drying shrinkage 11.5 per cent.
Average tensile strength about 105 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Linear Shrinkage.	Bulk Sp. Gr.	Hardness.	Color.
010	950	.396	−0.4 %	1.73	Soft burned.....	Salmon
08	990	.326	−0.4	1.73	Soft burned.....	Salmon
06	1,030	.336	−0.2	1.75	Soft burned.....	Salmon
04	1,070	.321	0.5	1.78	Soft burned.....	Light red
02	1,110	.288	0.6	1.72	Soft burned.....	Red
1	1,150	.276	1.1	1.80	Soft burned.....	Red
3	1,190	.260	2.3	1.86	Hard burned....	Dark red
5	1,230	.231	2.9	1.94	Hard burned....	Dark red
7	1,270	.193	3.0	1.89	Hard burned....	Red brown
9	1,310	.134	5.2	2.05	Hard burned....	Gray red
11	1,350	.040	5.6	2.06	Vitrified.....	Gray
13	1,390	.139	−2.9	1.61	Overburned.....	Gray

Brown gray clay, grainy in texture.
Burned by H. W. Jackman.

Two miles west of Avoca and about one mile southwest of the Pere Marquette R. R., in sections 5 and 8, T. 7 N., R. 15 E., the surface clay is yellow to red and blue in color, generally typical of this district. Sample No. 178 was taken at this place by trenching to a depth of five feet.

Burning Test.

Sample No. 178. Field Sheet No. 199.
Sections 8, 5, T. 7 N., R. 15 E.
Plasticity .273 gm. water per gm. clay.
Average linear drying shrinkage 6.2 per cent.
Average tensile strength about 129 lbs. per sq. in.
Apparent Dry Sp. Gr., 2.40.

Cone No.	Cone Temp. °C.	Porosity.	Apparent Sp. Gr.	Linear Shrinkage.	Hardness.	Color.
010	950	.354	2.67	+0.8 %	Soft burned.....	Salmon
08	990	.335	2.50	−0.6	Soft burned.....	Salmon
06	1,030	.324	2.49	+0.2	Soft burned.....	Salmon
04	1,070	.296	2.51	1.5	Soft burned.....	Salmon red
02	1,110	.234	2.52	4.9	Hard burned....	Red
1	1,150	.145	2.44	5.2	Hard burned....	Red brown
3	1,190	.125	2.42	5.0	Hard burned....	Dark brown
5	1,230	.081	2.36	7.6	Vitrified.....	Dark brown
7	1,270	.052	2.28	8.5	Vitrified.....	Dark brown
9	1,310	.159	2.12	1.9	Vitrified.....	Gray brown
11	1,350	....	....	....	Overburned	

Brown clay, molded easily.
Burned by H. W. Jackman.

This sample shows a wide burning range, uniform shrinkage, and burns to a good color at cone 02. It is free from stone and seems to be suitable material for the manufacture of face brick, and tile. Its vitrification range is not sufficient to recommend its use for vitrified ware, although such ware might be produced from this clay. This clay was probably derived from the Coldwater or Antrim shale which underlies the surface of St. Clair County and was redeposited by a plesitocene lake.

About 1½ miles west of Atkins, section 5, T. 7 N., R. 16 E., Fred Beard formerly made good common brick from the upper stratum of red burning clay.

In section 31, T. 7 N., R. 16 E., about one mile south of the Pere Marquette Railroad and 1½ miles north of the Grand Trunk Railroad, there is an outcrop of blue clay along the northeast bank of Pine River. The clay is covered with about three feet of sand and is at least 20 feet thick. Sample 179 was taken by trenching across the face of the outcrop.

Burning Test.

Sample 179. Field Sheet No. 200.
Section 31, T. 7 N., R. 16 E.
Plasticity 0.220 gm. water per gm. clay.
Average linear drying shrinkage 4.5 per cent.
Average tensile strength about 105 lbs. per sq. in.
Apparent Sp. Gr. air-dried brick 2.27.

Cone No.	Thermo-couple Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.394	2.75 %	2.66	Soft.....	Salmon
06	1,015	.350	−1.75	2.39	Soft.....	Salmon
04	1,070	....	....	....	Soft.....	Light red
02	1,110	.304	6.0	2.58	Hard.....	Light red
1	1,150	....	....	....	Hard.....	Light brown
3	1,195	....	....	....	Vitrified.....	Brown
5	1,225	....	....	....	Viscous	

Blue clay containing some lime pebbles, easy to mold.
Burned by M. C. Huck.

Sample 180 was taken from the upper 8 feet of a clay bank exposed along the sides of a creek about two miles west of Port Huron in section 5, T. 6 N., R. 17 E. The clay contains lime pebbles which were not removed in making the following test:

Burning Test.

Sample No. 180. Field Sheet No. 201.
Section 5, T. 6 N., R. 17 E.
Plasticity 0.173 gm. water per gm. clay.
Average linear drying shrinkage 3.4 per cent.
Average tensile strength about 110 lbs. per sq. in.
Apparent Sp. Gr. air dried brick 2.38.

Cone No.	Thermo-couple Temp. °Co.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	910	.403	−1.6%	2.77	Soft	Salmon
08	952	.364	−3.5	1.48	Soft	Salmon buff
06	1,015	Lime pop	....	....	Soft	Salmon buff
04	1,070	Lime pop	....	....	Soft	Salmon buff
02	1,110	Lime pop	....	....	Soft	Salmon buff
1	1,150	.294	0.5	2.86	Hard	Olive gray
3	1,195	Lime pop	....	....	Hard	Olive gray
5	1,225	Lime pop	....	....	Hard	Olive
7	1,250	Lime pop	....	....	Vitrified	Olive

Yellow clay. Numerous lime pebbles. Burned by M. C. Huck.

The New Egyptian Portland Cement Company has leased the old fort, at the river front in the northeastern part of Port Huron, formerly used as the railroad shops. The location was chosen because of its transportation facilities, being readily accessible to both railroad and water. The company is building a modern cement plant to have a capacity of about 6,000 barrels a day. When visited in August, 1923, the plant was just getting into operation with one kiln.

Limestone is shipped from Calcite (Rogers City), Presque Isle County, by water and unloaded and piled by a bridge type unloader. In 1923 clay was dredged from various places in the St. Clair delta south and west of Algonac and shipped to the unloading wharf at Port Huron. The river clay obtained in the St. Clair delta off Townsend's Coal Dock and under private royalty analyzed as follows:

Silica (SiO_2)	44.04%	44.36%
Alumina (Al_2O_3)	15.5	15.26
Iron (Fe_2O_3)	6.17	6.74
Lime (CaO)	12.61	14.60
Magnesia (MgO)	3.75	

The clay obtained under State royalty (sample 181) sections 14 and 23, T. 2 N., R. 15 E., from the St. Clair Delta, analyzed:

Silica (SiO_2)	49.56%
Alumina (Al_2O_3)	15.25
Iron (Fe_2O_3)	6.37
Lime (CaO)	8.03
Magnesia (MgO)	4.24

Analyses by Bateman, Chief Chemist New Egyptian Portland Cement Company.

Burning Test.

Sample No. 181. Field Sheet No. 202.
St. Clair River flats. Sec. 14 and 23, T. 2 N., R. 15 E.
Plasticity .322 gm. water per gm. clay.
Average linear drying shrinkage 10.1 per cent.
Average tensile strength about 121 lbs. per sq. in.
Apparent Sp. Gr. (dry) 2.57.

Cone No.	Cone. Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	950	.349	0.7%	2.55	Soft burned	Salmon
08	990	.361	+0.7	2.58	Soft burned	Salmon
06	1,030	.348	−0.2	2.52	Soft burned	Salmon
04	1,070	.331	+2.4	2.57	Hard burned	Salmon
02	1,110	.100	8.8	2.37	Hard burned	Brown gray
1	1,150	.025	8.6	2.14	Vitrified	Dark brown
3	1,190	.024	7.5	2.07	Vitrified	Dark brown
5	1,230	....	....	....	Viscous	

Blue clay. Molded easily. Suitable for brick and tile.
Burned by H. W. Jackman.

A sample of lake clay obtained from Smith's Creek, Section 31, T. 6 N., R. 16 E., on the Grand Trunk Railroad and easily accessible to the plant has about the same analysis as the clay obtained from St. Clair River off Algonac.

Silica (SiO_2)	45.76%
Alumina (Al_2O_3)	15.32
Iron (Fe_2O_3)	5.84
Lime (CaO)	9.22
Magnesia (MgO)	4.92
Loss on Ignition	14.47
	95.53

Analysis by Bateman, Chief Chemist, New Egyptian Portland Cement Co.

The clay received at the plant is unloaded and put through a disintegrator and washer, in which the clay is worked up to a slip containing about 60% water. The washed clay is then pumped into a storage tank.

The ground limestone and washed clay are then mixed and finely ground in a 3 compartment ball mill containing alloy steel balls 4 inches in diameter in the first compartment, 2½ inches in diameter in the second compartment, and 1¼ inches in the third compartment. This tube mill has ample capacity for a daily production of 2,000 barrels of cement, and requires about 500 H.P. to drive it. The ground slurry from this mill containing about 35% water is then pumped to storage tanks and is generally analyzed before being burned in the kiln.

The plans call for 3 kilns 11 feet in diameter and 200 feet long.

In 1923 one kiln was installed and operating. The kiln is fired with powdered coal and driven by a 90 H.P. motor. The slurry is fed to the mill by a feeder driven by the revolving kiln so that the feed is automatically stopped with the kiln. The gases leave the kiln at 600°-700°F. and are further cooled to 150°-200°F. in being drawn through a gas cooler and dust precipitator. The hot clinker discharged from the kiln is cooled by quenching in water and then conveyed to the clinker storage. The clinker is removed from storage as needed and ground in a three compartment ball mill similar in every way to the mill used in grinding the slurry. The ground clinker is transported to the packing room by a Fuller-Kinyon pneumatic conveyor. This system of conveying* consists in forcing a stream of powdered material (in this case ground clinker) into a small jet of compressed air by means of a worm pump similar to a screw conveyor. The quantity of air so mixed with the material is just sufficient to render the aerated mass fluid enough to be propelled through the distribution pipes by the pressure of the worm pump. Some troubles were experienced with the pumps when this system was first operated on the ground clinker.

Powdered slack coal is used as fuel for firing the kiln. The coal is first dried, then elevated to bins over the Fuller-Lehigh mills that are used to pulverize the coal. The plans call for 4 Fuller mills to handle the coal required by the three kilns. The powdered coal is conveyed to a bin at the kiln by the same Fuller-Kinyon system used on the ground clinker.

The St. Clair Brick Company's plant is just off River Road at the southwest corner of St. Clair north of the railroad in section 1, T. 4 N., R. 16 E. The plant is equipped to make soft mud brick with a hand dump molding machine, and drain tile with an auger machine. The green ware is dried in a steam heated drier. The brick are burned in oil fired scove kilns, and the tile in two coal-fired down draft kilns at the end of the kiln shed.

The clay bank is west of the plant across the river. The clay is a sandy red clay about 6 feet deep, underlain by sand and gravel. About 120 acres of land are owned by the company, 10 acres of which have been dug over. The clay is dug by a steam shovel and teamed to the plant. In June 1922 the plant was boarded up. Local information indicated that the plant was closed because of inability to keep labor at 50 cents an hour. The kiln yard still contained considerable brick although the plant operated only 3 months in 1921. The brick in the kiln were not of good quality but porous and cracked, as if the clay had been poorly prepared for molding. The clay is normally red burning but pockets of lime are encountered in the bank which cause many brick to burn

*Bur. Mines Bull. 217 (1923) Preparation, Transportation, and Combustion of Powdered Coal, John Blizard, p. 21.

buff. The following tests (sample 4) indicate that the clay is suitable for brick or tile and should give a good hard burned product at cone 04.

Burning Test.

Sample No. 4. Field Report Sheet 11. Sample of 6 feet.
Section 1, T. 4 N., R. 16 E., through bank.
Water of plasticity .268 gm. per gm. clay.
Average linear drying shrinkage 6.7 per cent.
Tensile strength of air dried samples about 206 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Fired Linear Shrinkage.	Hardness.	Color.
010	950	.340	0.5 %	Soft burned.....	Salmon
08	990	.340	2.1	Soft burned.....	Salmon
06	1,030	.348	2.4	Soft burned.....	Salmon
04	1,070	.207	3.7	Hard burned.....	Ligh brown
02	1,110	.188	5.8	Hard burned.....	Brown
1	1,150	.024	7.4	Vitrified.....	Dark gray brown
3	1,190	Cracked	....	Vitrified.....	Dark gray brown
5	1,230	.037	5.5	Vitrified.....	Dark gray brown

Easily worked and molded. Cracks easily on cooling.

Chemical Analysis.

Loss on Ignition	13.29%
Silica (SiO_2)	51.25
Alumina (Al_2O_3)	17.61
Iron Oxide (Fe_2O_3	4.94
Lime (CaO)	7.46
Magnesia (MgO)	1.57
Alkalies (Na_2O K_2O	3.88

Analysis by H. W. Jackman.

The Shriner Brick Company (Mr. Shriner, 379 Woodworth Avenue, Marine City), is located about one mile southwest of the St. Clair Brick Company in NW¼ section 7, T. 4 N., R. 17 E., on the outskirts of St. Clair. The clay is very similar to that used at the St. Clair Company's yard and the product is reported to be generally of about the same quality. The Shriner Brick Company was doing an active business in 1922 in an effort to supply the local market as the St. Clair Brick Company was not operating.

Sample 5 was taken from the upper five feet of a deposit of very plastic gray clay covering 30 to 40 acres or more in SW¼ section 18, T. 4 N., R. 17 E. The clay burns red and is hard burned at about cone 09. These properties make it a good material for brick and tile. When burned to higher temperatures, unless carefully oxidized, the bricks puff up in a very interesting manner. The outside of the brick seems to vitrify at a low temperature so that the interior cannot be oxidized. When heated to higher temperatures the gases cannot escape and make blow holes in the weakest part of the outer layer.

Chemical Analysis.

Sample No. 5. Sheet 12.
Upper 4 feet of deposit, SW¼ Sec. 18, T. 4 N., R. 17 E.

Loss on Ignition	5.24 %
SiO_2	60.00
Al_2O_3	22.00
Fe_2O_3	6.95
CaO	1.96
MgO	.71
Na_2O, K_2O	3.14

Burning Test.

Sample No. 5. Field Sheet No. 12.
Upper 4 feet of deposit in SW¼ section 18, T. 4 N., R. 17 E.
Plasticity .291 gm. water per gm. clay.
Average linear drying shrinkage 13 per cent.
Average tensile strength about 110 lbs. per sq. in.
Apparent Sp. Gr. (dry) 2.47.
Samples held at 425°C. for 7 hours to prevent hard burning of surface before carbon and sulphur compounds were completely decomposed.

Cone No.	Thermo-couple Temp. °C.	Porosity.	Linear Shrinkage.	Apparent Sp. Gr.	Hardness.	Color.
010	905	.385	0.4 %	2.77	Soft burned.....	Salmon red
08	945	.314	2.8	2.77	Hard burned.....	Salmon red
06	995	....	...	....	Hard burned.....	Salmon red
04	1,045	.176	4.0	2.60	Hard burned.....	Red
02	1,090	.108	8.5	2.51	Hard burned.....	Red brown
1	1,130	.056	8.5	2.41	Vitrified.....	Red brown
3	1,170	....	...	Bloated	Overburned.....	Brown
5	1,210	....	...	....	Viscous	
7	.....	....	...	....	Melted	

Easily molded.
Burned by M. C. Huck.

In 1921 Jos. Engleman of New Baltimore purchased the stiff mud brick machinery formerly used by Hucker at Mount Clemens and moved it to a clay bank on his property in east New Baltimore, north of the interurban right-of-way in section 7, T. 3 N., R. 15 E. His equipment consists of an oil burning engine, auger machine for extruding brick or drain tile with automatic cut-off for brick, an air drying shed with drop doors, and a small down draft coal fired kiln. The plant is operated only two or three months each year.

The clay runs about 15 to 25 feet deep over about 50 acres. The upper 3 feet is red clay which is underlain by a few inches of lime pebbles and

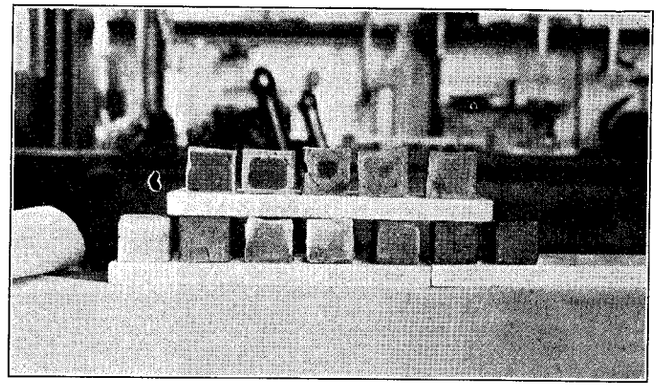

Plate XLI, Figure 1.—Bituminous shale (Antrim) from East Jordan and Chestonia. Upper five samples show hourly progress of oxidation. Lower seven samples show results of burning to cones .014, .010, .08, .06, .04, .02 and 1 respectively. The third and fourth from the left show white discoloration.

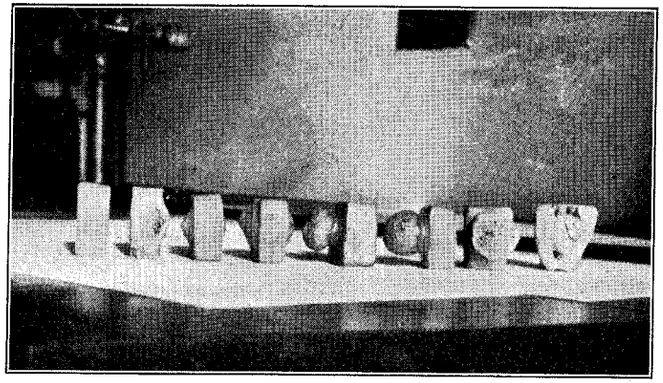

Plate XLI, Figure 2.—An interesting exhibit of the results of incomplete oxidation. This clay becomes hard burned at a low temperature. The pressure exerted by the gases, liberated in the interior as the temperature was raised, blew bubbles in the weakest part of the softening exterior.

then a plastic blue clay over 15 feet thick. The land is low and will probably present a drainage problem. The clay is dug by means of a scoop drawn along the surface by the stationary engine. Sample 6 is of the upper red burning clay above the lime pebbles.

Chemical Analysis.

Sample No. 6. Sheet 13.
Main clay deposit in section 7, T. 3 N., R. 15 E.

Loss on Ignition	3.60%
Silica (SiO_2)	72.27
Alumina (Al_2O_3)	15.05
Iron Oxide (Fe_2O_3)	4.58
Lime (CaO)	.95
Magnesia (MgO)	.43
Alkalies (Na_2O, K_2O)	3.12

Analysis by H. W. Jackman.

Burning Test.

Sample 6. Sheet 13.
Section 7, T. 3 N., R. 15 E.
Upper red clay.
Plasticity .263 gm. water per gm. clay.
Linear drying shrinkage 7.5 per cent.
Average tensile strength about 120 lbs. per sq. in.

Cone No.	Cone Temp. °C.	Porosity.	Absorption.	Fired Linear Shrinkage.	Hardness.	Color.
010	950	.311	.175	−0.7 %	Soft burned....	Light red
08	990	.310	.174	−1.0	Soft burned.....	Light red
06	1,030	.301	.168	−0.7	Soft burned.....	Light red
04	1,070	.283	.152	0.7	Hard burned....	Red
02	1,110	.200	.099	1.5	Hard burned....	Dark red
1	1,150	.147	.068	4.8	Hard burned....	Brown red
3	1,190	.095	.043	6.0	Vitrified	Brown red
5	1,230	.089	.040	5.9	Vitrified.....	Brown red
7	1,270	.063	.028	7.2	Vitrified.....	Brown red
9	1,310	.217	.129	−3.3	Partly melted...	Dark steel

Easily molded, making a smooth even colored brick.

Good material for face brick or tile, and might be used for vitrified ware.

Burning test by H. W. Jackman.

The analysis suggests that the clay is in part, at least, probably derived from the shale that underlies this part of the State. The burning test indicates that the sample is good clay for all forms of brick or tile. It has a burning range of ten cones and is suitable for face brick and might be used for vitrified ware.