MINES BRANCH
DEPARTMENT OF THE INTERIOR.
HONOURABLE FRANK OLIVER, M.P., MINISTER.

PRELIMINARY REPORT

ON THE

Industrial Value of the Clays and Shales of Manitoba.

BY

J. WALTER WELLS.

OTTAWA, CANADA.

1905.

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OTTAWA, May 4th, 1905.

SIR,—

I have the honour to transmit herewith a Preliminary Report on the industrial value of the Clays and Shales of Manitoba.

I have the honour to be,

Sir,

Your obedient servant,

(Sgd.) EUGENE HAANEL,

Superintendent of Mines.

HON. FRANK OLIVER, M.P.,

Minister of the Interior.

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OTTAWA, 18th March, 1905.

SIR,—

I have the honour to transmit herewith a preliminary report on the industrial value of the Clays and Shales of Manitoba. About two months were spent in the field examining the raw materials and the present methods adopted to utilize them.

I have the honour to be,

Sir,

Your obedient servant,

J. WALTER WELLS.

DR. EUGENE HAANEL,

Superintendent of Mines,

OTTAWA.

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PREFACE.

This report, involving two months field work in Manitoba, is an attempt to serve the following purposes:—

(1) To give an idea of the distribution, character and chemical composition of the clays and shales of Manitoba.

(2) To give a short account of the brick-making industry in Manitoba with some suggestions for reducing the cost and improving the product.

(3) To show further practical uses for the clays and shales in Manitoba.

The report is not complete, as all of the brick-making plants in the Province were not examined. It is hoped, however, that it is sufficient to show that the deposits of clay and shales are a valuable asset to the Province, worthy of further development, for the manufacture of brick, terra cotta, sewer and drain pipes, tiling, cement, etc., as substitutes for wood in building constructions.

The increasing demand for cheap and durable building material will call for the use of large quantities of brick and other clay products.

I.—SOME POINTS REGARDING THE CLAYS AND SHALES IN MANITOBA.

Clay is a natural hydrated silicate of alumina more or less impure. It is chiefly known by its property of forming a plastic mass when mixed with water and forming a hard mass after subjection to a red heat or higher temperature.

When clays are subjected to pressure under natural conditions, often with mineral waters percolating through fissures in the mass, they are formed into hard, compact *shales*, which, except in hardness, possess the same qualities as clay, being very plastic when pulverized and mixed with water.

Shales are formed into slate by heat and pressure. Fine, pulverized slate mixed with water has no plasticity.

ORIGIN.

The shales of Manitoba are very ancient, having been formed during the earlier geological periods as sedimentary deposits derived from the decomposition of felspathic rocks of the western mountains and elsewhere. Those formed during the Cretaceous period are the most abundant in the Province.

Primary or residual clay derived from the decomposition of felspathic rocks *in situ* is reported to exist on the east shore of Lake Winnipeg, but the deposits are probably small in size.

The clays of sedimentary origin are derived from the erosion of the beds of shale by the action of water at various periods and from the decomposition of boulders of felspathic rocks deposited by glacial action.

The clays derived from the glacial erosion of the shales and also from the decomposition of felspathic boulders brought down from the north by glacial action were deposited and afterwards rearranged by water action in the lower parts of Manitoba; such as the Red River Valley.

MINERALOGICAL COMPOSITION.

Since clay and shale are derived from the breaking down of many other rocks, a large number of accessory minerals are present in addition to kaolinite or hydrated silicate of alumina which is the primary constituent of clay, present in large quantity in residual clay or kaolin and in smaller quantity in sedimentary clays.

Most of the clays and shales in Manitoba contain a few small white and yellow particles of kaolin, possibly derived from the decomposition of felspathic boulders after deposition. These require further crushing and dissemination through the mass, as, when they are present as lumps, they are liable to crack brick and other clay products in burning. Quartz in the form of small rounded or angular grains is the most abundant accessory constituent of clays, which may be separated out as coarse sand by washing and screening the pulverized clay or shale. Sand also includes other gritty siliceous matter and serves to lessen the shrinkage of the clay in burning.

Feldspar, hornblende and pyroxene are common constituents of clays, especially those recently formed from the decomposition of igneous rocks. They serve to prevent shrinkage of clay in the burning process up to their fusion point and after fusion they increase the shrinkage.

Mica in the form of small, amber-colored scales with brilliant surfaces is a common constituent of clay. It is not readily fusible and increases the refractoriness of the clay.

Lime carbonate in the form of finely divided chalk or marl, small grains or pebbles is a common constituent of clays and shales in Manitoba. It is often present in the concretions known as clay dogs.

The marl bearing clays make a cream colored brick, in which the lime carbonate acts as a flux.

The Cretaceous shales of Niobrara formation carry finely divided chalk, either as small white specks scattered through the gray shale or as segregations of yellowish chalk.

If lime carbonate occurs as pebbles or in concretions it should be pulverized by passing the clay through crushing rolls, followed by thorough mixing, as the under-burned lumps are sure to slake and crack the brick.

The presence of finely divided lime carbonate up to 20% is not injurious to brick clays. In clays and shales used for sewer pipe and paving brick the lime carbonate should be present in small quantity and finely pulverized.

The presence of lime carbonate may be detected by the effervescence produced when cold hydrochloric acid is brought into contact with the substance containing it; in the case of dolomite effervescence occurs only when hot acid is applied.

Gypsum (sulphate of lime) in the form of small, soft scales with a pearly lustre is usually present in the shales and clays in Manitoba. It serves as a flux when present in small quantities but may decompose in the burning process and blister the clay product when present in large quantity. In hard burned bricks it merely acts as a flux but in under-burned bricks it is liable to produce soluble alkaline sulphates which may cause a white coating on the weathered brick.

Siderite (iron carbonate) is usually present in the Pierre shales as concretions commonly called clay iron stone. It should be crushed finely before the shale is used as it is very easily fused, causing inequalities in the burnt clay product.

Marcasite and pyrite (sulphides of iron) are present in the shales of Manitoba, either as small nodules known as "sulphur balls" or as streaks of finely divided pyrite between the layers. Glacial clays do not often carry sulphides of iron, as it has decomposed into limonite. They should be pulverized in the preliminary preparation and finely disseminated through the mass, since they act as strong fluxes and cause blistering of the burned clay product when present as segregations.

Limonite (hydrated iron oxide) is always present in the clays and shales of Manitoba, often as coatings. Limonite may be derived from the decomposition of sulphides of iron (pyrite and marcasite) and iron bearing silicates such as hornblende. It colors the clay and shale yellow and reddish brown and serves to produce a buff and reddish color in the burned clay product.

CHEMICAL COMPOSITION.

Pure kaolin has the following composition:—

Combined water	13.93%
Silica	46.50
Alumina	39.57

Such clay is never found naturally in commercial quantity, as impurities such as sand, ferric oxide, lime, magnesia, soda, potash, titanium and organic matter are generally present in small or large quantity.

Two kinds of silica may be present:—1st. that in combination with alumina in kaolin, 2nd. as sand and finely divided silica. The sand may carry free silica as quatrz or combined silica in feldspar and mica.

Free silica as grains of quartz or finely divided is present in all the clays and shales of Manitoba in quantities varying from 1% up to 50%. It serves to lessen the plasticity, prevents shrinkage both in drying and burning of clay products, but lessens the tensile strength of the raw clay.

Iron oxides such as limonite and hematite are always present in clays and shales and serve as a fluxing agent in burning, also as a coloring agent both in raw and burned clay.

All of the iron compounds are converted into ferric oxide in the burning process with an oxidizing flame and according to the amount present the brick may vary in color from cream to deep red.

Lime is usually present in the clays and shales of Manitoba as carbonate (marl, chalk, pebbles of limestone and dolomite) but small quantities may be present in combination as complex silicates and as sulphate (gypsum).

Lime acts as a powerful flux and should not be present in large quantity in clays and shales used for paving brick and sewer pipe as it causes fusion to a slag soon after vitrification. It also slightly reduces the shrinkage of clays in burning and tends to counteract the coloring effect of iron oxides producing a cream or buff colored brick when iron oxides alone would color the brick a deep red.

Magnesia is present in the clays and shales, from traces up to 10%. The Cretaceous shales are remarkably free from magnesia. It seems to have the same action as lime in clay products.

The alkalies, soda and potash, are always present, from traces up to 4%, either in the form of undecomposed grains of feldspar, hornblende or mica, or as chlorides and sulphates.

When present as silicates they act as strong fluxes, binding the clay product into a compact mass.

The alkaline chlorides and sulphates produce white efflorescence on bricks which may be counteracted by adding barium carbonate to the raw clay.

Titanium compounds such as rutile and ilmenite are generally present in small quantities, not more than ½%.

Water is always present in clays and shales as moisture and chemically combined water. In general the combined water is one-third of the percentage of the alumina present. It is driven off at red heat in burning, the clay product being reduced in volume from 2 to 10%. Clays which have lost the water of combination by burning are not plastic.

Moisture is present in varying amounts. Air dried clay requires from 10% to 30% water added to make it plastic.

Organic matter is present as decayed vegetation and as bituminous matter. The calcareous shales carry bituminous matter formed from the remains of small forms of animal life such as foraminifera.

PHYSICAL PROPERTIES.

The most important physical properties of clays and shales affecting the industrial uses are slaking, plasticity, tensile strenght shrinkage in dry and burning, color and action under heat.

SLAKING.

All clays slake or crumble into a finely comminuted mass when sufficient water is added. Shales being harder and more compact slake much slower under the action of water but when exposed to the combined action of water, frost, air and heat, such as under ordinary weather conditions, they slake rapidly into small fragments and finally into clay, as may be seen at the La Riviere brick yards.

Clay workers make use of this property by allowing stiff clay and shale to remain exposed during the winter season, but more often the raw shale is finely pulverized by machinery for immediate use.

PLASTICITY.

Plasticity is the property which natural clays and finely pulverized shales possess when water is added of forming a pasty or plastic mass which may be moulded into any shape.

Highly plastic clays are termed rich and those having a low degree of plasticity are termed lean. The addition of fine sand reduces the plasticity of clays.

In general, the highly plastic clays and shales are more suitable for sewer pipes, terra cotta and stoneware; those of medium plasticity are suitable for paving brick; while the lean, sandy clays are suitable for common brick.

TENSILE STRENGTH.

Tensile strength is represented by the resistance shown to forces tending to cause tearing apart of the clay particles in moulding and drying.

The very plastic pottery clays show the highest tensile strength and the common brick clays the lowest.

SHRINKAGE.

Shrinkage of clay products is a reduction in volume caused by water being evaporated in air drying and by mechanically and chemically combined water being driven off in the burning process. A low air shrinkage is desirable as there is less danger of the clay product warping or cracking in drying.

The more plastic the clay the more shrinkage, so that sand is often added to brick clays to reduce the shrinkage, securing a product of uniform size. Fire shrinkage should be as low as possible and evenly distributed so that the burned product will not be distorted.

COLOR.

The color of raw clay and shale is not a criterion of its value or suitability for making a certain grade or color of burned clay product.

For example, a clay carrying iron oxides in large quantity may have the color of the iron oxides obscured by organic matter giving it a grayish color. A large amount of finely divided lime carbonate may cause a clay to burn into a buff colored product which otherwise would be reddish.

A large quantity of marl present in clay may cause it to resemble fire clay, but in the actual fire test it may be quite fusible. Gray shales are often considered as refractory because resembling grayish fire clays.

The color of the burned clay product depends on its composition as already shown and on the method of burning, that is, whether it is subjected to a reducing or to an oxidizing heat and the intensity to which it is burned.

ACTION UNDER HEAT.

When clays and shales are subjected to a red or a higher temperature a softening or fusion of the particles is produced with elimination of all volatile constituents such as water, organic matter and carbon dioxide.

Chemical action occurs between the silicates acting as acids and alumina, lime, magnesia, iron, soda, potash, etc., acting as basic elements. Mechanical rearrangement of the particles also occurs with a shrinkage in the total volume of the mass.

When the red hot mass is allowed to cool the product is a dense, hard, compact material which cannot be cut readily with a knife and which possesses no plasticity when finely pulverized and mixed with water.

Clays and shales do not all act alike under heat. Some brick clays soften or fuse rapidly and at a low heat and are called fusible; others, such as pottery or fire clays, fuse only after long continued burning at a high temperature and are called refractory.

Clay workers seek to maintain a heat suitable for the raw material and the best method of working clay or shale into a saleable article is largely a matter of experiment as two clays may have the same chemical composition and yet act differently in the moulding and burning processes.

II.—DISTRIBUTION AND CHARACTER OF CLAYS IN MANITOBA.

The clay deposits in Manitoba having any industrial value are of sedimentary origin. Specimens of primary residual clay, said to occur as small deposits on the east shore of Lake Winnipeg near Bad Throat River and handed to the writer by local settlers, were found to consist of white kaolin with a small quantity of quartz, probably derived from the decomposition of felspathic rocks such as granites and syenites which make up the country rock of Lake Winnipeg.

Sedimentary clay is generally distributed over the surface of Manitoba east of Lake Winnipeg, the layers varying in thickness from 2 feet to 40 feet or more.

The surface soil of Manitoba consists generally of black clay loam carrying considerable decayed vegetable matter which makes it remarkably rich and productive.

The clay suitable for brick and other clay products underlies the surface capping. It usually carries fine yellow sand segregated in pockets, alternate layers and thin irregular seams.

The clays derived from the local erosion of Cretacious shales are fairly pure and often of considerable depth. They are best shown in the coulees and at the base of the Pembina Hills, Tiger Hills, Riding, Duck and Porcupine Mountains.

According to origin the clays may be arranged in the following descending order:—

GEOLOGICAL SUMMARY OF MANITOBA CLAYS.

POST TERTIARY.	*Post Glacial.*—	(1) Present lake beaches. Delta deposits from rivers flowing into lakes.
		(2) Reassorted boulder clay, such as at Lac du Bonnet Brick Works.
		(3) Local deposits derived from the erosion of Cretaceous shales.
	Glacial.—	(1) Yellow and blue upper stratified clays of the Red River Valley, derived from the erosion of Cretaceous shales on the Manitoba escarpment and also from the rearrangement of boulder clay in the process of deposition.
		(2) Boulder clay on the general surface and often below the upper stratified layer of rearranged sedimentary clay.
TERTIARY.	*Laramie Formation.*—Clay underlying lignite coal in Turtle mountains.	
CRETACEOUS.	Shales of various composition and often of great thickness, laid down in prehistoric times.	

The character of some of the clay deposits may be seen from the following descriptions:—

Lac du Bonnet Brick Yards.—The pit sunk for a depth of 20 feet on the banks of the Winnipeg River shows the following layers of reassorted boulder clay free from boulders and large pebbles in descending order:—

Surface covering of black clay loam................	3 feet
Yellow plastic clay with small streaks and pockets of fine grained quicksand and a few small limestone pebbles....................................	10 "
Rich, black, stiff clay with little sand, but carrying particles of kaolin..........................	8 "

Borings have shown this layer to extend 30 feet below the present workings.

The chemical composition of both layers is given further on. The clay in the upper layer produces a cream colored brick, while the bottom layer makes a reddish, denser brick.

Clay on the shores of Lake Winnipeg.—On the west shore of Lake Winnipeg several deposits of rearranged boulder clay were noted. At Bull Head Harbor a bed of dark, stiff, rich, stratified clay extends for a height of 8 feet above the water level and runs along the shore for 200 yards. The clay is practically free from boulders and pebbles but carries a few streaks of fine sand and should make a fine grade of reddish, hard, tough brick.

A small deposit of similar clay was noted on the south shore of Black Island and similar deposits are reported on the east shore.

Red River Valley Clay.—The Red River Valley is underlaid by beds of clay 30 feet or more in thickness and derived from the glacial erosion of Cretaceous shales and from the decomposition of the detritus brought down from the north by the action of glaciers.

An examination of the clay at eight brick yards on both sides of the river near Winnipeg showed the following layers in descending order of clay practically free from boulders and large pebbles:—

Surface soil, black clay loam.	3 to 5 feet
Brownish-yellow, plastic, irregularly stratified clay, containing about 25% of fine-grained sand and a few small limestone pebbles intimately mixed through the layers	2 to 5 feet
Stiff, rich, brownish, slightly stratified clay practically free from pebbles and sand, but heavily charged with lime, magnesia, iron oxides and alkalis	22 feet.

The upper layer makes a cream colored brick by the soft mud process without any further addition of sand. The lower layer is not used as it is too stiff and rich, but should make a tough, durable brick of reddish color by the proper process of tempering and burning.

At the Carman Brick Yard, on the banks of the Boyne River, Carman Station, C.P.R., the clay bed, apparently of glacial formation, shows the following layers in descending order, boulders and pebbles being practically absent:—

Surface capping, black clay loam	4 feet
Dark, stiff, rich clay with a few streaks and pockets of fine sand	3 "
Yellowish-brown, plastic clay more or less mixed with sand and a few pebbles	3 "
Fine grained, dark-yellow sand	Unknown depth.

The face of the pit showing the layers is well shown in the accompanying photo, Plate 4.

Clay of the same character was also noted at the water tank, Rose Isle Station, Canadian Northern Railway.

This material makes an excellent grade of light red, tough, durable brick.

Miscellaneous Deposits.—At the LEARY BRICK WORKS, LEARY SIDING, CANADIAN NORTHERN RAILWAY, the open cut on the banks of the Boyne River shows a bed of dark blue-gray colored clay free from boulders, gravel and sand, but containing a few limestone pebbles and a few crystals of selenite. It is evidently derived from the erosion of Pierre shales and is said to extend to a depth of 375 feet. It is overlaid by a surface covering about 2 feet thick, consisting of black clay loam and sand.

The clay when tempered with sand makes an excellent grade of hard, tough, red brick.

At Blackwood's Brick Yard, Edran's Station, C.N.R., the working face of the clay pit and deeper borings show the following layers in descending order, being practically free from gravel:—

Surface capping, black clay loam	18 inches
Yellow clay, free from streaks and pockets of sand, but containing finely divided lime carbonate and a few limestone pebbles.	3 feet
Light brown, rich, stiff clay, containing small irregular streaks and pockets of finely divided sand and often limonite (hydrated iron oxides) in streaks. White kaolin as small concretions and a few limestone pebbles are scattered through the deposit	22 feet.

The upper layer makes a hard, tough, buff colored brick by the soft mud process and burning in scove kilns, while the bottom layer makes a more refractory brick of reddish color by the same process.

At Davis' Brick Yard, Sidney Station, C.P.R., the working face of the clay pit shows the following layers in descending order, being free from boulders, gravel and limestone pebbles:—

Surface capping, black clay loam	2 feet
Yellowish-brown, rich, stiff clay, free from sand . . .	6 feet
Fine sand as an irregular layer.	1 foot.
Sandy clay.	Unknown depth.

The clay makes an excellent grade of hard, tough, red brick by the soft mud process, burning in scove kilns.

At Sampson's Brick Yard, Brandon, the clay pit shows 2 feet of black, sandy clay loam covering 5 feet of dark yellow, slightly stratified clay containing a small quantity of fine grained lime carbonate and a few streaks of sand. Gravel and limestone pebbles are rarely seen.

The clay when tempered with 30% of fine sand makes an excellent grade of white brick by the soft mud process and burning in scove kilns.

At Stephen's Brick Yard, Portage la Prairie, alongside the C.P.R. and C.N.R. tracks, below the surface capping of black clay loam 3 feet thick is a bed 14 feet thick of yellowish-gray, plastic, slightly stratified, uniform clay, free from gravel and coarse sand. The clay when properly tempered with sand makes a fine grade of white brick by the soft mud process, burning being done in down draft kilns.

At Wainwright's Brick Yard, Virden, the deposit, 40 feet thick and overlaid by 8 inches of black, sandy, clay loam, consists of yellowish brown, plastic, uniform clay intimately mixed with fine grained sand. A little alkali shows near the surface, but gravel and limestone pebbles are practically absent.

The clay when properly tempered with sand makes a fine grade of buff colored, tough, durable brick by the semi-dry process, wire cutting and burning in scove kilns.

At Young's Brick Yard, Souris City, on the top of a high hill overlooking the Souris River, the irregularily stratified clay shows remarkable rearrangement and deposition due to water action, in the following descending order:—

Black surface soil		1 foot.
Wavy layers of yellow clay carrying a few pebbles and streaks of fine sand		2 feet.
Yellow and brown clay in irregular alternate layers, free from pebbles and layers of sand	Dark, fat clay 1″ Yellow clay 6″ Dark, fat clay 1″ etc.	4 feet.

At Wilson's Brick Yard, Gladstone, the clay is yellowish, plastic, carrying a slight admixture of fine sand, but free from visible signs of iron oxides and lime carbonate. The bed is 6 feet thick, covered by 12 inches of black clay loam and overlying a bed of very sandy clay. The clay makes an excellent grade of cream colored, durable brick.

At Eastman's and Rowlett's Brick Yard, Gilbert Plains, located on section 12, township 25, range 22, west, the surface covering of black clay loam is only 12 inches and the clay is yellowish, uniform, fairly pure, with only a small quantity of sand. It has been tested to a depth of 16 feet. A similar deposit is located near Ethelbert Station, C.N.R.

At Hale's Brick Yard, Rapid City, located 1½ miles from the railway station, a bed of fairly pure clay thirteen feet thick occurs in layers quite free from sand, which seems to be segregated into alternate layers and irregular seams.

At the Deloraine Brick Yard, a bed of yellowish, sandy clay is found immediately below the surface covering of black clay loam. A few small limestone pebbles are present. The clay makes a cream-colored, rather hard brick by soft mud moulding and burning in scove kilns.

ANALYSES OF MANITOBA CLAYS.

	Moisture	SiO_2 Free and combined.	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O K_2O	SO_3	Undetermined. CO_2 Organic Matter Combined Water, etc.		Total.
1	3.35	45.43	10.67	4.78	10.50	6.03	2.04	0.13	org. mat.	17.07	100.00
2	4.65	48.51	17.10	5.60	5.12	4.75	2.83	0.35	....	11.09	100.00
3	8.92	49.00	18.15	6.61	3.09	2.74	2.26	0.11	1.16	9.12	100.00
4	——	51.27	9.33	3.52	11.15	2.31	2.58	....	——	19.84	100.00
5	3.50	50.84	10.46	3.34	12.25	2.71	1.98	0.08	0.17	14.84	100.00
6	3.10	58.53	9.88	2.77	11.34	1.70	2.35	0.05	0.43	10.28	100.00
7	3.65	57.28	17.39	3.95	2.70	1.50	2.90	0.43	2.00	10.20	100.00
8	...	56.28	30.25	3.00	3.28	trace	1.89	3.13	....	2.17	100.00
9	3.46	62.67	9.72	3.41	7.32	2.71	1.44	0.34	....	9.93	100.00
10	8.66	54.00	9.25	2.77	9.77	3.51	2.34	0.05	0.30	9.65	100.00
11	3.25	71.13	11.52	4.50	1.75	1.25	3.25	0.05	0.10	3.30	100.00
12	3.32	56.18	9.87	3.20	8.19	3.95	2.20	0.07	0.45	13.02	100.00
13	4.00	50.66	10.00	3.43	10.00	3.10	2.31	1.80	0.34	14.70	100.00
14	1.50	45.15	9.05	3.75	14.00	7.11	2.52	0.10	....	16.82	100.00

(1) Yellowish, reassorted boulder clay from open cut, Lac du Bonnet Brick Works, sampled by the writer in 1902 and analysed by the Government Assayer for Ontario.

(2) Black, fissile clay, 50 feet below the surface, Lac du Bonnet Brick Works. Sample obtained by the writer from the original borings, 1902, and analysed by the Government Assayer for Ontario.

(3) Top layer, clay bank, west side of Winnipeg River, 2 miles up stream from Lac du Bonnet Brick Works. Sampled by the writer and analysed by M. F. Connor.

(4) Red River clay, free from sand, Alsip's Brick Yards, Grand Forks, North Dakota. Analysed by State Chemist of North Dakota.

(5) Average sample from clay pit, Carman Brick Yards. Analysed by M. F. Connor.

(6) Sample of clay from banks of stream, Rose Isle Station, C.N.R. Analysed by M. F. Connor.

(7) Clay derived from erosion of Pierre shales taken from a new railway cutting on the C.N.R., Boyne River Valley. Analysed by M. F. Connor.

(8) Sample from open cut at Leary's Brick Yards, Leary Siding, C.N.R. Analysis made by E. B. Young of Winnipeg, on a dried sample furnished by the owners.

(9) Yellow clay 4 feet below surface at brick yards, Deloraine. Sampled by the writer in 1902, and analysed by the Government Assayer for Ontario.

(10) Yellowish-gray unstratified clay free from sand and gravel at Stephen's Brick Yards, Portage la Prairie. Analysed by M. F. Connor.

(11) Average sample of yellowish clay from clay pit, Davis' Brick Yards, Sidney. Analysed by M. F. Connor.

(12) Pure clay free from sand at Davis' Brick Yard, Sidney. Analysed by M. F. Connor.

(13) Average sample of yellowish clay free from sand and gravel, from open cut at Virden Brick Yards. Analysed by M. F. Connor.

(14) Average sample of yellowish clay from Eastman's Brick Yards, Gilbert Plains. Analysed by M. F. Connor.

III.—DISTRIBUTION AND CHARACTER OF THE SHALES IN MANITOBA.

Clay shales of the Cretaceous geological period occur in Manitoba from the Pembina River Valley at the International boundary northward in the Pembina and Tiger Hills and make up the hills in north-western Manitoba known as the Riding, Duck and Porcupine Mountains.

The Cretaceous shales may be classified according to the following geological table in descending order:—

PIERRE FORMATION.	*Odanah Series.*—Light gray, hard, fissile, poor in fossils, weathering into rusty, small, irregular fragments; found in the Pembina Valley, Pembina Hills, Tiger Hills, and in the upper portions of the hills in north-western Manitoba. *Millwood Series.*—Dark gray, soft, often carrying small fragments of selenite, pyrite and clay-iron stone, occurring in the hills in north-western Manitoba.
NIOBRARA FORMATION.	Light gray, mottled, calcareous, carrying more or less siliceous yellow chalk as bands or segregations. Everywhere containing the remains of foraminifera as small yellow-white specks scattered through the gray shale. Generally found outcropping at the bottom of coulees and streams in the hilly sections of Manitoba.
BENTON FORMATION.	Dark gray, soft, non-calcareous, poor in fossils. Found below the calcareous shales in the hills in north-western Manitoba.

The writer noted shales belonging to the upper and lower Devonian in north-western Manitoba, but they occur as small deposits and are of little commercial value.

BENTON SHALES.

Outcrops of shale of the Benton formation were not noted by the writer but are reported at the base of the Riding, Duck and Porcupine Mountains in north-western Manitoba. As the lowest member of the series they are likely to be covered by surface detritus eroded from the upper beds.

NIOBRARA SHALES.

The Niobrara formation of the Cretaceous period extends from Texas northward through Arkansas, Nebraska, South and North Dakota, and is reported north-west of the boundaries of Manitoba.

The Niobrara formation contains dull gray, soft, calcareous shales often running into bands of soft, yellow chalk.

A characteristic feature of the formation is the presence of the remains of numerous foraminifera as small, yellow-white specks scattered through the gray shale. Thin bands of hard, gray limestone containing numerous fragments of white shells are often found.

The writer noted outcrops at the following points:—

(1) In the Tongue River Valley, Cavalier County, North Dakota, particularly at the plant of the Pembina Portland Cement Company, where it is mined for the manufacture of high grade natural cement.

(2) In township 1, range 6, west, near the International boundary, as shown in the accompanying photograph, Plate I. The Pembina River runs at the bottom of a deep and wide valley flanked on both sides by steep cliffs of Pierre shales overlying Niobrara shales.

Two test pits and several borings sunk by the Manitoba Cement Company showed 40 feet of horizontally bedded, fine grained, uniform, slate gray colored shale free from sand but mottled by numerous white specks, the remains of foraminifera. A bed of cream-colored, soft, dry chalk is in place at the top of the cliff, as shown in the photo, extending about 100 feet along the cliff with an average thickness of 12 feet.

(3) In the coulees of the Pembina Hills near Arnold, especially on Cumming's farm, Moore's farm and on Pilling's property. The C.N.R. at Arnold Station runs over a deposit which is mined for the manufacture of natural hydraulic cement. Similar outcrops were noted on the banks of a stream two miles north of Deerwood.

(4) On the banks of the Boyne River, section 15, township 6, range 8, west, within 100 yards of the C.N.R.

Outcrops are reported by J. B. Tyrell (Geological Survey Report, 1890-91):—

(1) In the valleys of all the streams on the north side of Riding Mountain from the Ochre to the Valley Rivers.

(2) On the banks of North Pine Creek, Duck Mountains.

(3) On the banks of Swan River and its tributaries.

(4) On the face of Thunder Hill, Swan River Valley.

(5) On the streams flowing from the eastern and northern slopes of Porcupine mountains.

The Canadian Northern Railway runs close to the outcrops in north-western Manitoba.

CHEMICAL COMPOSITION OF NIOBRARA SHALES.

The varying composition of the calcareous shales is represented by the following analyses:—

	(1)	(2)	(3)	(4)
Moisture	1.84	2.11	——	——
Silica, combined and free	20.10	16.16	32.50	18.77
Alumina	8.20	6.60	14.80	15.59
Ferric oxide	3.41	2.45	1.09	0.70
Lime	33.76	35.11	40.00	44.47
Magnesia	0.78	trace	trace	trace
Alkalis	1.23	1.72	trace	0.37
Sulphur trioxide	0.64	3.80	0.40	3.26
Carbon dioxide	17.21	26.04	11.00	16.00
Combined water	12.65	5.61	Undetermined	Und.
Organic matter				1.00
	99.82	99.60	99.79	100.16

	(5)	(6)	(7)
Moisture	1.50	3.32	2.30
Silica, combined and free	27.02	13.83	20.67
Alumina	9.32	5.99	8.70
Ferric oxide	4.00	2.59	3.14
Lime	30.28	40.97	33.23
Magnesia	0.50	0.38	0.50
Alkalis	1.38	0.66	1.20
Sulphur trioxide	0.10	0.88	0.49
Organic matter	0.41	7.36	0.63
Carbon dioxide	26.27	24.50	28.77
Combined water			
	100.78	100.48	99.63

(1) Dark, mottled shale with patches of soft chalk, from Pilling's test pit in cement rock, Arnold, C.N.R., sample selected by the writer in 1902 and analysed by the Government Assayer for Ontario.

(2) Average sample of dark shale from Pilling's test pit in cement rock, Arnold, C.N.R., sampled and analysed as in No. 1.

(3) Calcareous shale from Leary's pit No. 2, section 15, township 6, range 8, west, Boyne River Valley, about 300 yards west of Leary Siding, C.N.R. Dried sample analysed by E. B. Young for the owners, Leary Land Company, Winnipeg.

(4) Sample from Leary's cement rock deposit, Boyne River Valley, about one mile west of No. 3. Analysis of dried sample by E. B. Young for the owners, Leary Land Company, Winnipeg.

(5) Cement rock, located in section 15, township 6, range 8, west, underlying the C.N.R. track and exposed along the banks of the river. Sampled by the writer and analysed by M. F. Connor.

(6) Calcareous shale outcropping on the bank of Boyne River, below No. 5. Sampled by the writer and analysed by M. F. Connor.

(7) Same location as No. 3. Sampled by the writer and analysed by M. F. Connor.

PIERRE SHALES.

The Pierre formation consists of dull gray, fine grained, tough, fissile shales, classified as the Odanah series, and softer, darker shales, often carrying clay-ironstone and small fragments of selenite, classified as the Millwood series.

The writer noted outcrops of Pierre shales at the following points:—

(1) On the banks of Pembina River, 15 miles south of Morden, and also from Mowbray up the river for 20 miles at different points. The high hills at La Riviere consist of tough, fine-grained, uniform, gray shale, breaking down into fine scales. Nodules of kaolin and a few streaks of sand and pyrite are present. The surface weathers a rusty gray.

(2) On the banks of Assiniboine River from Oak Lake to Virden.

(3) In the upper portion of Pembina Hills and Tiger Hills.

(4) On the banks of the Souris River below Souris City.

They are also reported at the following points:—

(1) At high cliffs on the banks of Ochre and Vermillion Rivers and Edward's Creek on the north face of Riding Mountain.

(2) On the south bank of Big Creek, a tributary of Big Grassy River, in section 8, township 17, range 15, west. The outcrops of shale at this point are at least 120 feet thick, consisting of soft, uniform, slate gray, fissile shale, free from sand, but carrying a few streaks of pyrite which decomposes, staining the shale a rusty gray in spots.

(3) On North Pine and Bell Rivers, on the east side of Duck Mountains.

(4) At numerous points on the east and north faces of Porcupine Mountain.

ANALYSES OF PIERRE SHALES, MANITOBA.

	(1)	(2)	(3)	(4)	(5)
Moisture / Combined water } above 100° C.	9.71	6.06	6.78	8.25	10.94
Silica	68.14	79.55	81.94	78.32	61.22
Alumina	8.18	8.35	6.52	7.11	18.90
Ferric oxide	4.10	1.90	2.40	2.59	3.70
Lime	1.67	1.50	0.80	0.91	0.70
Magnesia	1.65	1.02	0.93	1.28	1.10
Alkalis	2.01	1.17	1.30	1.11	3.39
Sulphur trioxide	0.39	not given	0.16	0.05	0.23
Carbon dioxide	1.44	not given	traces	traces	traces
Organic matter, etc.	3.00	not given	traces	0.29	traces
	100.29	99.55	100.83	99.91	100.18

(1) Odanah shale free from sand at La Riviere Brick Works. Sampled by the writer in 1902, and analysed by the Government Assayer for Ontario.

(2) Compact, light, bluish-gray, tough, smooth shale from the Pierre formation near Souris City, Souris River. Sample collected by Dr. Selwyn, and analysed by F. G. Wait. (Report of Geological Survey Department, 1892-93).

(3) Compact, light gray, fissile shale, free from sand, from south bank of Big Creek, a branch of Big Grassy River, north-west corner of section 8, township 17, range 15, west, in Riding Mountain, and analysed by M. F. Connor.

(4) Pierre shale, found by the writer on banks of Assiniboine River, 3 miles north of Virden, and analysed by M. F. Connor.

(5) Pierre shale from cliff, Pembina River Valley, south of Morden, property of Manitoba Cement Company. Analysis by M. F. Connor.

IV.—THE BRICK-MAKING INDUSTRY IN MANITOBA.

Beds of clay suitable for making common and pressed brick occur in all parts of Manitoba and at convenient points near railways, villages, towns and cities the clay is being made into building bricks.

COMMON BUILDING BRICK.

The method of making common brick may be shown by the following:—

MINING	Horse power scrapers. Ploughing. Caving or undermining.	
HAULAGE.	Carts. Wheelbarrows. Tram cars.	
TEMPERING.	Often enough sand in the clay as streaks and pockets. Addition of 10 to 30% of fine sand. Addition of water to secure plasticity.	
PREPARATION	Exposure to air during winter season. Crushing rolls followed by a pug mill. Stiff mud augur mixer. Soft mud augur mixer.	
MOULDING.	Soft mud pressing, using horse and steam power.	Martin press. New Monarch press. Baird's press. Pott's press.
	Stiff mud pressing and wire cutting.	Fresee's machine.
DRYING.	Covered yards without pallets, about 1 week air drying. Covered yards on pallets, about 5 days air drying.	
BURNING.	Scove kilns, soft wood as fuel.	Water smoking, 2 to 4 days. Hard burning, 4 to 6 days.
	Rectangular down-draft kiln using soft wood as fuel.	Water smoking for 3 days. Hard burning for 4 days.
PRODUCT.	Sorted into two grades:— 1. Common filling brick selling at about $9.00 per M. 2. Selected facing brick selling at about $11.00 per M. The color of the brick varies from a light cream color, due to the large amount of lime and magnesia present, to a medium red color, due to iron oxides present. The bricks are generally of fair quality but when the clay carrying limestone pebbles is not passed through crushing rolls, concretions of lime are present which unite with moisture in the air, expanding and cracking the bricks. Sometimes the bricks are soft, owing to excess of sand present and also to underburning.	

THE EXTENT OF THE INDUSTRY IN MANITOBA IS SHOWN BY THE FOLLOWING TABLE:—

Location	Operator.	Tempering.	Moulding.	Drying.	Burning.	Approximate capacity per Season, (150 days)	Character of Brick.	Shipping Facilities and Remarks.
Lac du Bonnet...	W. Tallman, Superintendent.......	Fine sand added, crushing rolls	Soft mud press	Pallets in covered yard	Scove kiln...	3,000,000	Cream color, hard ...	C.P.R. alongside the kiln.
St. Boniface....	W. Alsip & Sons....	No sand added, crushing rolls	"	"	"	12,000,000	Cream color, medium soft	Wagon hauling to Winnipeg.
"	Kelly Bros. & Co ..	"	"	"	"	12,000,000	Cream color, medium soft	" "
"	McCutcheon & Co...	"	"	"	"	8,000,000	" "	" "
"	W. Broughton.....	No sand added	"	"	"	2,000,000	" "	" "
"	M. Lamontagne..	"	"	"	"	4,000,000	" "	" "
"	Couture Bros......	"	"	"	"	4,000,000	" "	" "
"	Saul & Irish......	"	"	"	"	3,000,000	" "	" "
"	Press Brick & Tile Co..........	"	"	"	"	2,000,000	" "	" "
Winnipeg.......	Winnipeg Brick Co..	"	"	"	"	3,000,000	" "	" "
"	Standard Brick & Tile Co..........	"	"	"	"	1,000,000	" "	" "
Carman	P. Allan..........	Sand added, no rolls	"	"	"	1,000,000	Light red, medium hard	Local demand supplied
Leary Siding	G. Leary.......	Sand added - augur mixer	"	Pallets in drying house	"	1,000,000	Light red, medium hard, lime in brick	C.N.R. to Winnipeg. Plant not in operation.

		no rolls						
Leary Siding	G. Leary	Sand added - augur mixer	"	Pallets in drying house	"	1,000,000	Light red, medium hard, lime in brick	C.N.R. to Winnipeg. Plant not in operation.

Stony Mountain	Penitentiary	Sand added	Soft mud press	Pallets in covered yard	Scove kiln	1,000,000	Cream color, rather soft	For local demand.
Sidney	E. Davis	"	"	"	"	1,000,000	Bright red, medium hard	For local use, makes a good red pressed brick.
Portage la Prairie	H. Stephens	10% sand added in malaxor	"	"	Down draft rectangular kiln	8,000,000	Cream color, hard, tough excellent brick	C.P.R. and C.N.R.
" "	Snider Bros	Sand added	"	"	Scove kiln	1,000,000	Cream color, medium hard	Local trade.
" "	J. R. McDonald	"	"	"	"	1,000,000	Cream color, medium hard	Local trade.
Edrans	Blackwood & Co	20% sand added	"	"	"	1,000,000	Light red, rather hard	C.N.R. alongside the kiln, would make a good pressed brick.
Somerset	Longbottom & Co	Sand added	"	"	"	800,000	Cream color, medium hard	Local trade, C.N.R.
Altamont	Snowdon & Co	"	"	"	"	600,000	Cream color, medium hard	Local trade.
Holland	F. H. Dagg	"	"	"	"	1,000,000	Cream color, medium hard	Local trade, C.P.R.
Cypress River	J. Ruston	"	"	"	"	1,000,000	Cream color, medium hard	Local trade.
Pilot Mound	T. Deerlove	"	"	"	"	1,000,000	Medium hard	Local trade, C.P.R.
Deloraine	A. B. Land	Little sand added	"	"	"	1,000,000	Cream color, medium soft	Local trade, C.P.R.
Brandon	Sampson & Co	25% sand added	"	"	"	1,800,000	Buff color, hard, durable	Local trade, C.P.R.
Sec. 14, T. 19, R. 17	R. J. Dennic, Douglas P.O.	Sand added	"	"	"	150,000	Light red, rather soft	Local farm use.
Virden	Wainwright & Co.	Sand added, augur mixer	Stiff mud press wire cutting	Covered yard, no pallets	"	1,500,000	Reddish, rather hard	Local trade and C.P.R.

THE EXTENT OF THE INDUSTRY IN MANITOBA—*Continued.*

Location	Operator.	Tempering.	Moulding.	Drying.	Burning.	Approximate capacity per Season, (150 days)	Character of Brick.	Shipping Facilities and Remarks.
Hartney	W. Kirkland	Sand added	Soft mud press	Pallets in covered yard	Scove kiln	1,000,000	Rather soft	Local trade.
Souris	Young & Co.	"	"	"	"	1,000,000	Light red, rather hard, lime pebbles in brick	Local trade.
Russell	J. Edel	"	"	"	"	500,000	Rather hard, fair quality	Local use.
Neepawa	J. A. Roberts							Not in operation since 1898.
Rapid City	R. Hales	No sand needed	"	"	"	1,500,000	Cream color, rather hard	Local use.
Gladstone	M. Wilson	"	"	"	"	800,000	Cream color, rather hard	Local use.
Gilbert Plains	Fastman Bros.	Sand added,	"	"	"	900,000	Cream color, rather hard	Local use, C.N.R.
"	T. Rowlett	"	"	"	"	230,000	Cream color, rather hard	Local use. C.N.R.
Fort Francis, Ontario	Dowker & Co.	25% sand added, augur mixing	Stiff mud press wire cutting	"	"	100,000	Reddish, hard, tough, excellent brick	C.N.R. to Winnipeg. The clay would make excellent pressed brick.

DRY PRESSED BRICK.

Pressed bricks for building and ornamental purposes are made at Lac du Bonnet and La Riviere by the following methods:—

	Lac du Bonnet.	La Riviere.
Raw Material.	Lower layer of reassorted boulder clay.	Pierre shale.
Mining	Undermining by shovels.	Undermining by blasting.
Haulage	Scoop carts	Travelling link buckets.
Tempering	No sand added	No sand added.
Drying.	Drying floor of iron plates	No drying needed.
Pulverizing.	Dry pan, broken soft burned brick added as grog.	Williams' disintegrator.
Screening.	Stationary tilted screen, with holes 1/10″ in diameter.	Tilted travelling Dunlop screen, with holes 1 18″ in diameter.
Oversize	20% oversize returned to the dry pan.	60% returned to disintegrator.
Moulding	Eureka press, 4 bricks at one pressing. Boyd press, 2 bricks at one pressing.	Boyd press, 6 bricks at one pressing.
Drying.	Hot air drying chamber for 3 to 5 days.	Dryer not in operation.
Burning	7 days burning in:— (1) Circular down-draft kilns, using soft wood as fuel; 10% of bricks are culls. (2) Scove kilns, using soft wood as fuel; 30% of the bricks are culls.	14 days burning in circular down-draft kilns, using Estevan lignite coal as fuel; 10% of the bricks are culls.
Capacity per day (10 hours).	30,000	20,000.
Shipping Facilities.	C.P.R. alongside the kiln	C.P.R. alongside the kiln.
Character of Product.	1st grade: buff color, hard, compact, sharp edges, smooth, tough. A very superior brick. 2nd grade: pinkish color, rather soft and sometimes checked. 3rd grade: common kiln run, checked and irregularly colored; burnt in scove kilns.	1st grade: dark reddish-brown, hard, tough, fine-grained, smooth, sharp edges. Altogether a superior brick. 2nd grade: yellowish-buff color with green streaks, where vitrification has occurred, very hard, tough, smooth. Excellent brick. 3rd grade: light reddish, rather soft, free from checks, rather crumbling. 4th grade: common kiln run, consisting of cracked, undersized and underburned brick of different colors.

SUGGESTIONS FOR IMPROVING THE QUALITY AND REDUCING THE COST OF PRODUCTION OF BRICKS.

Small pebbles of limestone and kaolin are common impurities of Manitoba clays and as they have a damaging effect on the burned brick they should be pulverized by passing the raw clay through heavy crushing rolls and thoroughly intermixed through the mass.

At the La Riviere brick yards the product could be improved by finer grinding of the raw shale, introducing crushing rolls and a dry pan in addition to the disintegrator already in use.

Sand in amounts varying from 10% to 40% is added at many of the brick plants using soft mud process since it makes the raw clay easier to work up and reduces the shrinkage. However, it lowers the strength of the burned brick.

Stiff mud pugging machines and wire cutting of the pugged clay allow a greater output than soft mud moulding but the burned bricks are liable to have spiral and irregular laminations unless the clay has been thoroughly mixed.

Since most of the common brick produced in Manitoba are burned in scove kilns, using as fuel soft cord wood, which is becoming more expensive, it would be useful to know how far compressed straw blocks could be used as a fuel. Immense quantities of straw are annually burned in the open field. The straw is dry, burns readily and can be compressed into fuel blocks by machinery such as made by the Canadian Straw Fuel Machine Company, Alliston, Ontario.

The rectangular down draft kilns, such as shown in Plate No. 5, and used at Stephen's Brick Yards, Portage la Prairie, produce a higher grade of brick at about the same cost in comparison with scove kilns.

The Hoffman continuous ring kiln, burning soft coal dust, has reduced the cost and improved the product in European and American brick plants. It would be useful to test the value of lignite coal fines such as thrown on the waste dumps in the Estevan coal fields for burning brick in the Hoffman kiln.

The Hoffman continuous brick kiln (see Plate 8) consists of an arched annular chamber divided by moveable partitions into sections. The raw bricks are built up in this chamber allowing for draught and fire openings.

The fuel (coal dust) is added through the small holes in the top, as shown in the vertical section and the plan. The fuel is only fed into that section of the kiln which is under full heat and when the bricks in that section are burnt firing is started in the next section, thus constantly travelling around the circle.

Fresh air enters the section which is being emptied about four compartments ahead of the full fire and in passing the burnt brick it becomes gradually heated while at the same time it cools the burnt brick up to the section which is under full fire. After combustion of the coal dust, the resulting gases pass through the other sections giving off heat to the raw brick. They leave the kiln from the last and newly charged section and pass to the chimney located in the centre of the kiln.

In Plate No. 8, *aa* is the annular chamber with doors, *bb*, or openings for charging the brick and divided into sections by dampers, *cc*; *d* is the main flue connected with the kiln by smaller flues, *e* and *i*.

The fuel is charged through the openings, *gg*, which are closed by bells in a sand seal; *hh* are openings for the dampers *cc* and are sealed with clay.

The fuel costs for this kiln are low, since most of the heat is utilized.

The construction of this kiln is expensive and it is rather difficult to keep the flues in repair.

The output is large in comparison with scove kilns, fuel and labour costs considered, and the loss of brick as culls is less than 10%.

Continuous brick kilns built in the form of a tunnel and using coal dust or producer gas as fuel are being generally adopted by European and American brick makers as giving a high grade, evenly burned product at a low cost and little loss of brick as culls.

Such kilns are best adapted for use in western Manitoba, at Souris and Brandon, where coal dust from the Estevan coal fields can be laid down at a low cost.

The general construction of the tunnel kiln may be seen in Plate No. 9. The tunnel is built of common brick and lined with fire brick with a two inch air space between the lining and the outside.

The chimney is usually built at the feeding end of the tunnel. The raw bricks are loaded on iron trucks fastened together and covered with fire brick. The trucks are moved slowly through the tunnel on a track and forced by endless screw or cable. The tunnel is divided into two sections, one above the other, as shown in the illustration, and communication between the upper and lower parts of the tunnel is cut off by sand seals. The fire-boxes are on top of the kiln and the fuel (coal dust) is added as necessary, the whole operation of burning being under complete control as the kiln admits regulation of air, fuel and speed of the trucks through the tunnel.

At the chimney end of the tunnel openings admit fresh air, which, passing under the trucks, helps to keep the cars cool. At the other end of the tunnel the air passes around and up over the end of the truck and returns to the chimney through the brick, allowing the proper amount of air for combustion. By means of dampers, the necessary amount of air is admitted.

The capacity of the kiln is large and the cost of a kiln burning 10,000 common building bricks per 24 hours is about $2,500, including track and trucks. Such a kiln requires 140,000 bricks for construction.

The cost of burning brick in the tunnel kiln varies with the locality, price of fuel and labor. It is safe to say that a tunnel kiln in western Manitoba will produce common and pressed brick at a lower cost than the scove and down draft kilns and give a product equally as good as the other kilns.

V.—SOME USES FOR CLAYS AND SHALES IN MANITOBA.

COMMON, PRESSED AND HOLLOW BUILDING BRICK.

The use of clays and Pierre shales for making common and pressed brick has already been refered to. Calcareous shales of the Niobrara formation are of little value for making brick.

Hollow building blocks are not made in the Province although it has been shown that the Pierre shales and the clay derived from its erosion at La Riviere and Walhalla, North Dakota, will make hollow building blocks, as shown in Plate No. 7.

Hollow bricks are usually larger than common bricks and sometimes they have a rectangular cross-section, but usually there are one or two partitions making two or four divisions in cross section. The cheap, plain forms are used for foundations, stables, houses, stores, etc. The advantages claimed for the hollow brick are: (1) that the brick can be made much larger without excessive weight, (2) economy of material and weight without sacrificing strength.

PAVING BRICK.

Some of the heavy, rich, plastic, fusible clays found as bottom layers in reassorted boulder clay may make paving brick.

The Pierre shales alone will not make paving brick, as they are too refractory, but when finely pulverized and mixed with more fusible clays they will produce a compact, dense, vitrified product, impervious to water and resisting abrasion. A good site for a paving brick plant is at Souris City, using Pierre shale and surface clay as raw materials.

There is a wide field in Manitoba for the use of paving brick.

FIRE BRICK.

The clays underlying lignite coal in the Turtle Mountains may produce fire brick.

The bricks produced from Pierre shale at La Riviere are very refractory and can be used in place of fire brick for many purposes.

Deposits of fire clay are not reported in Manitoba.

SEWER AND DRAIN PIPES.

The rich stiff clays, free from sand, at Lac du Bonnet, Saint Boniface, Fort Francis, in Ontario, and other points have been used to make ordinary unglazed drain tile.

The Pierre shale at La Riviere when used alone is not suitable for salt glazed sewer pipe. Experiments conducted on a large scale at the Lac du Bonnet Brick Works during the summer of 1904 with the object of making sewer pipe from the shale gave the following results, as noted by the writer:—

(1) The material readily takes uniform salt glazing.

(2) The glazed surfaces show different colored spots—white, yellow, pink, green and brown—proving that the shale consists of different varieties of silicate of aluminum, from white kaolin to reddish fusible clay, and contains mineral coloring agents, such as manganese compounds.

(3) The burned clay lacks body, having a porous structure and the surface is irregularly cracked instead of the uniform, compact, dense, vitrified texture of good sewer pipes.

(4) Mixture of Pierre shale with Estevan clay and Moose Jaw fire clay gave better products. A good site for a sewer pipe factory is at Souris City where Pierre shale and fusible clay are available and fuel from the Estevan coal fields is cheap.

TERRA COTTA FIRE-PROOFING.

Some of the richer fusible clays mixed with the Pierre shales are suitable for terra cotta fire-proofing material, for which there is considerable demand. Highly plastic clay making a first grade front brick is suitable for terra cotta.

Terra cotta lumber and fire-proofing resemble hollow brick in some respects, but are porous and open in texture in order to give them light weight for use in floors and wall partitions. The porosity is obtained by mixing sawdust in the clay which is burnt out in the burning process, thus leaving small pits in place of the sawdust particles.

They are hollow and can be bound together by steel rods or bands. The use of this material is rapidly increasing as a fire-proof substitute for wood in floors and wall partitions.

CHIMNEY FLUES AND POTS.

Chimneys are now built of square hollow blocks with small holes at each corner for the vertical binding rods.

Some of the richer clays will make satisfactory hollow chimney blocks.

GLAZED AND ENCAUSTIC TILES.

When the demand for ornamental floor, wall, chimney and roofing tile increases it may prove profitable to manufacture glazed and encaustic tiles from the Pierre shales mixed with suitable clay.

COARSE POTTERY.

Coarse unglazed clay products such as flower pots, vases, etc., are made at Doidge's Pottery, East Selkirk, from local clay. Salt glazed pottery such as stoneware jugs are also made from a mixture of the local clay with Moose Jaw fire clay.

PORTLAND AND NATURAL HYDRAULIC CEMENT.

Any of the calcareous shales will make a fair grade of natural hydraulic cement by calcining in vertical kilns and grinding the clinker to a fine powder.

The calcareous shales in north-west Manitoba of uniform composition and practically free from sand, magnesia and sulphates should be suitable material in combination with high grade limestone for the manufacture of Portland cement. Similar shales are used as raw material for Portland cement in Michigan and Kansas (see Report on the Cement Industry of Manitoba).

MINERAL PAINTS.

Clays free from sand and carrying a high percentage of iron oxides will make a fair grade of red and yellow ochre by calcining. The glacial clays are not suitable for ochres as they carry a large amount of sand.

ROAD-MAKING MATERIAL.

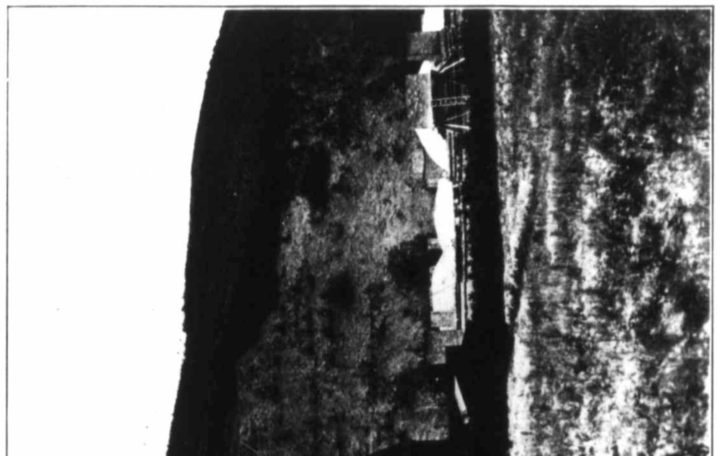
Pierre shale has been used at Oak Lake as a road-making material and gives fair service, especially on sandy roads. The tough, compact shales are better road material than softer shales. Clay makes a fair road when mixed with sand and gravel.

Several of the western American railroads make track ballast by burning surface clay, using old railway ties as fuel.

PLATE I.

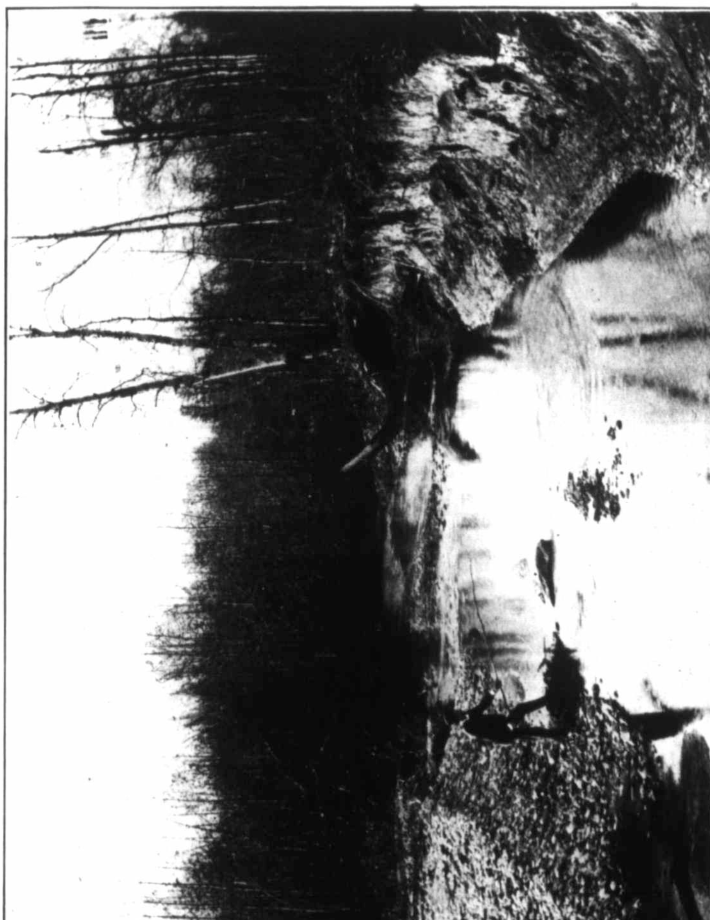
OUTCROP OF CALCAREOUS SHALE AND CHALK (NIOBRARA FORMATION) IN PEMBINA RIVER VALLEY, TOWNSHIP 1, RANGE 6, WEST, MANITOBA.

PLATE 2.



A HILL AT LA RIVIERE CONSISTING OF PIERRE SHALE USED FOR THE MANUFACTURE OF PRESSED BUILDING BRICK IN THE PLANT, AS SHOWN.

PLATE 3.

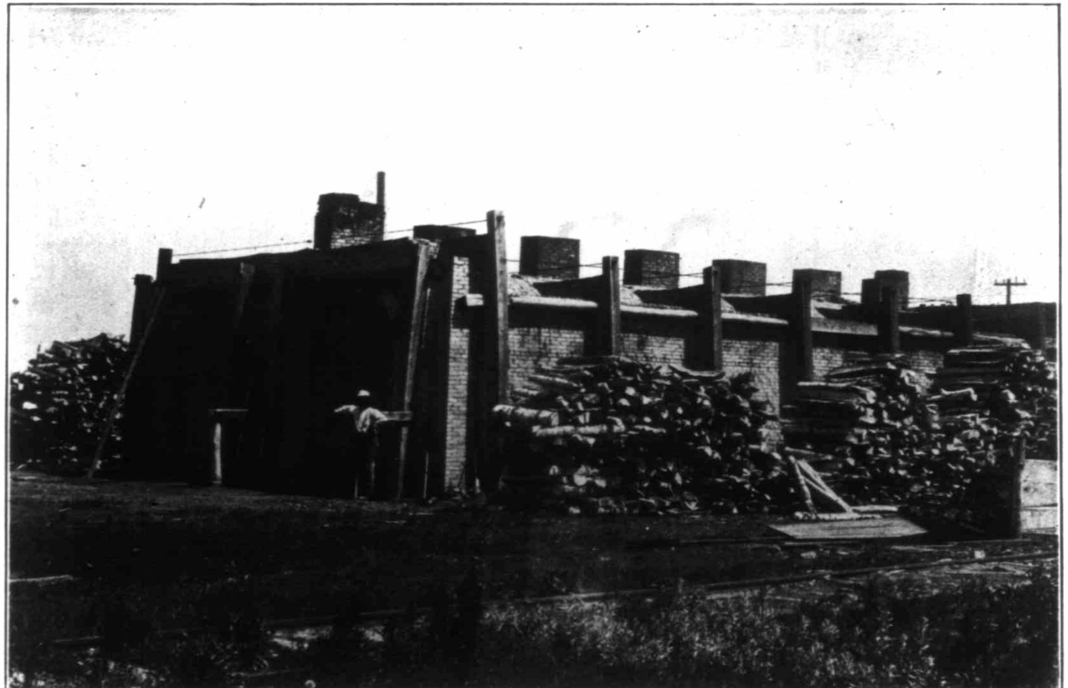


STRATIFIED CLAY OVERLYING BOULDER CLAY, EAST FAVEL RIVER, NEAR MINITONAS.

PLATE 4

STRATIFIED REARRANGED RED RIVER VALLEY CLAY, OVERLYING SAND AT CARMAN BRICK YARDS

Plate 5.

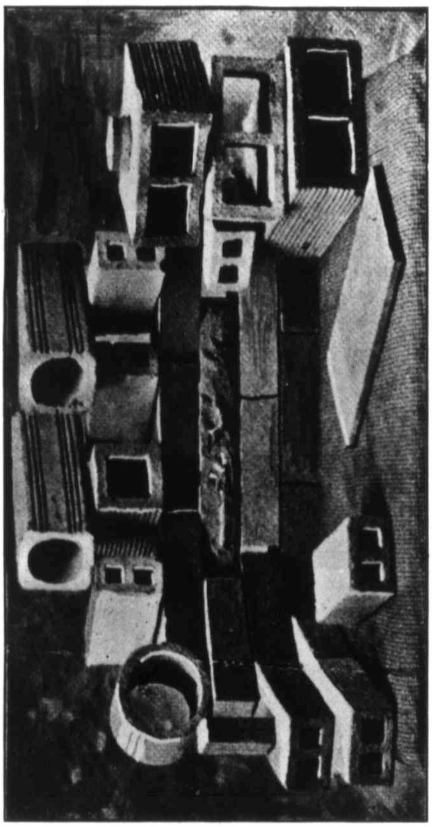


Up and down draft rectangular kiln used at Stephen's Brick Yard, Portage la Prairie, for burning bricks, made by soft mud process.

PLATE 6.

PALLET DRYING AND SCOVE KILN BURNING OF BRICK MADE BY SOFT MUD PROCESS AT BRANDON BRICK YARDS.

Plate 7.



Samples of the products of Pierre shale and clay derived from its erosion, made at Walhalla Brick Yards, North Dakota, just south of the Manitoba boundary.

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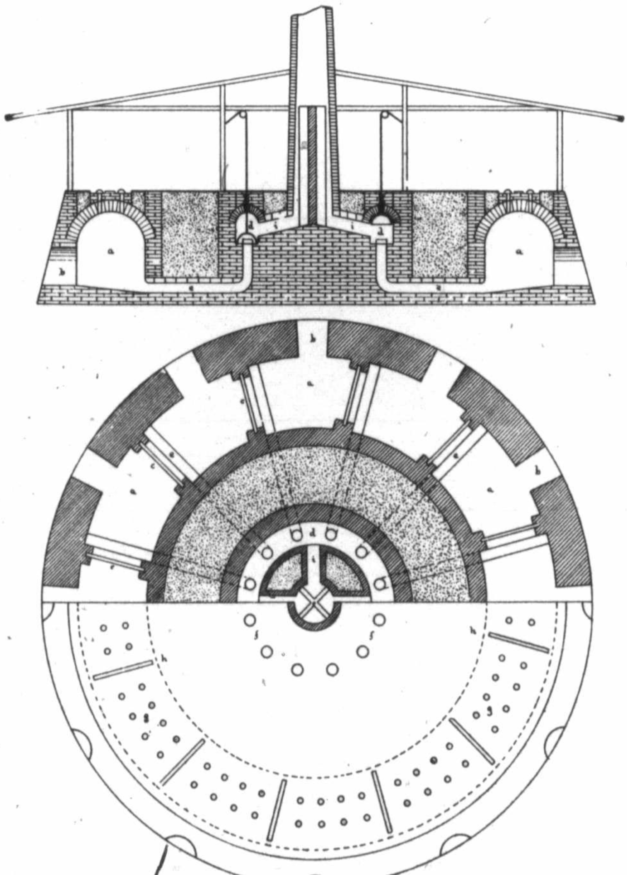
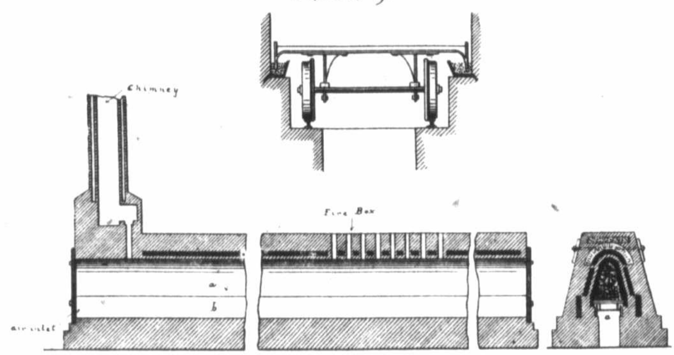
PLATE 8.



DRAWING SHOWING VERTICAL SECTION, HORIZONTAL SECTION AND PLAN OF THE HOFFMAN CONTINUOUS CIRCULAR DOWN DRAFT BRICK KILN.

PLATE 9.



TUNNEL KILN FOR BURNING BRICK USING COAL DUST AS FUEL