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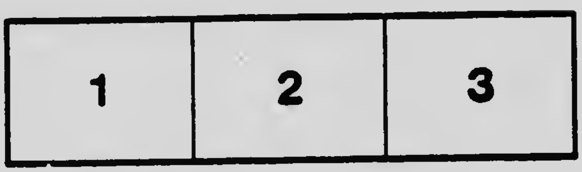
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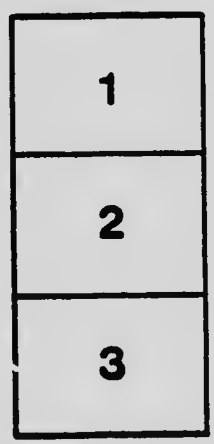
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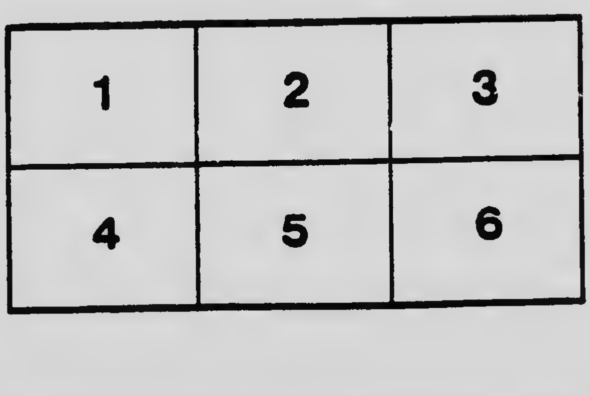
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CANADA

DEPARTMENT OF MINES

HON. ARTHUR MEIGHEN, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

MINES BRANCH

EUGENE HAANEL, PH.D., DIRECTOR.

Report on the Clay Resources of Southern Saskatchewan

BY

[illegible] DAVIS, M.A., B.Sc.

OTTAWA
GOVERNMENT PRINTING BUREAU
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Panoramic v[illegible] of Eagle butte, in the Frenchman River valley, near Ravenscrag, Sask., showing Whitemud beds at the base of the section.

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PREFACE

The following report on the "Clay Resources of Southern Saskatchewan" was prepared by Mr. N. B. Davis, Assistant Engineer, Ceramic Division. The report is based on field work carried on during the seasons of 1915 and 1916, and on laboratory tests conducted in the ceramic laboratory of the Mines Branch during 1915, 1916, and 1917, in accordance with my instructions. Its publication is a further contribution to our knowledge of the economic minerals of Canada, and may be deemed specially opportune at the present time, when the commercial demand for refractory materials is—and has been for years past—altogether in excess of the supply. The greater part of the supply was obtained from foreign sources.

The Province of Saskatchewan excels in the quality and quantity of that class of raw refractories known as fireclays; and in addition to this valuable material, possesses other argillaceous deposits, from which can be manufactured practically the whole range of structural clay products; a fact of vital importance to a region almost entirely devoid of native timber and building stone.

The report of Mr. Davis contains information not only regarding the geological position, exact locality, and availability of each deposit from which the clay samples were collected, but gives an account of the behaviour of the materials tested in the laboratories; thus determining, scientifically, their qualities, and adaptability for use in the clayworking industry.

(*Signed*) **Joseph Keele.**
Chief Engineer, Ceramic Division.

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REPORT ON THE CLAY RESOURCES OF SOUTHERN SASKATCHEWAN

CLAY RESOURCES OF SOUTHERN SASKATCHEWAN

INTRODUCTORY.

The following report is the result of field investigations and laboratory tests on samples of clay collected in that part of the Province of Saskatchewan lying south of the 51st parallel. During the summers of 1915 and 1916 some one hundred and sixty samples of clay were collected and tested in the laboratory during the following winters, short reports of progress being given in the summary reports of the Mines Branch for those years.

Previous work on the clays of the area consisted of preliminary economic surveys by Dr. H. Ries and Mr. Jos. Keele, and general geological work by Mr. Bruce Rose on the Wood Mountain-Willowbunch coal district. The results of their investigations pointed out tne need of a more intensive study of the clay resources.[1]

The clays of the western provinces often prove defective in their drying qualities, and prospective workers are advised to be particularly careful in making this test under commercial conditions.

It is well known that small scale laboratory tests only serve to indicate the desirability of making larger tests on a commercial scale. The records of tests included herein are, therefore, but a first step, and are not to be taken as conclusive evidence of the value of any particular clay for manufacturing any particular article. If a clay is defective to any extent the laboratory tests will reveal where the defect lies, and point to the best methods of overcoming the trouble. If the clay can be worked in the laboratory without difficulty, or the defects can be readily overcome, it is safe then to consider tests on a commercial scale in some existing plant located outside the range of competition.

In the field work I had the hearty co-operation of the clayworkers of the Province and of those outside the Province interested in this resource. In particular I wish to mention Mr. F. Newcombe of the Estevan Coal and Brick Co., Mr. J. H. Kern of the Dominion Fire Brick and Clay Products Co., and Mr. R. P. Stewart and Mr. John Dixon of the Alberta Clay Products Co.

In the laboratory I had the invaluable direction of Mr. Jos. Keele, Chief Ceramic Engineer.

Further, I wish to acknowledge the kindness of Mr. Jas. McCabe, of the Frontenac Floor and Wall Tile Company, Kingston, and of Mr. R. New, of the Toronto and Hamilton Sewerpipe Company, Hamilton, in burning test pieces in their commercial kilns.

[1] Ries and Keele: Geol. Surv. of Canada, Memoirs 24E, 25, 66. Rose: Geol. Surv. of Canada, Memoir 89.

THE CLAYWORKING INDUSTRY.

Saskatchewan is comparatively a new Province with respect to the rest of the Dominion. Within the last fifteen years settlement has been very rapid, and the handiest and easiest materials of construction have been used. In the early days there was a lack of stone or wood for the construction of places of habitation for man and beast, hence the settler turned to the sod, and built himself rude shelters of this material.

With the dissemination of the knowledge that the prairie lands promised rich harvests of grain, small settlements, favourably located regarding transportation, rapidly grew to towns and cities. During this feverish and optimistic period building materials of the best were required in abundance, and at short notice. The resources of the Province were unknown, and established structural materials were looked for in the American market. In supplying this demand the American brick makers as far south as St. Louis, and east to Pennsylvania, reaped a harvest. While this rush was on, only two common brick plants and two face brick plants were in operation, and that for only part of the time.

On the strength of the boom a plant was built at Claybank before the coming of the Canadian Northern railway to the locality, but, unfortunately, the railway was not available until the wane of the building boom. This plant at Claybank, owned by the Dominion Fire Brick and Clay Products Co., has turned out a fine range of flashed brown face brick, made by the dry-press process from the refractory clays of the Fort Union formation. At present, the company is concentrating on the production of refractories, and the outlook is very promising. The product made should be equal to the standard firebrick imported from the United States.

One of the oldest and largest plants in the Claybank area is that of the Estevan Coal and Brick Company, located on the bank of the Souris valley, one mile south of Estevan. It is producing an excellent red face brick made by the dry-press process, and common, buff, stiff-mud brick.

Six miles south of this, at Shand station, the Maple Leaf Mines, Ltd., (Shand Coal and Brick Co.) operate a stiff-mud brick plant, using buff-burning calcareous clays. The product is an excellent grade of common wire-cut brick.

At Weyburn, the Weyburn Brick Company operated a dry-press and stiff-mud plant for a number of years; but it has been shut down since 1914. The raw materials present some difficulties, and, should the plant be operated again, it would be well to consider using the refractory clays of Yellow Grass and Halbrite.

East of Weyburn, at Arcola, the Arcola Brick Works operate a stiff-mud brick plant for making common buff brick.

In the oldest settled part of the Province, along the main line of the Canadian Pacific railway, several small, soft-mud brick plants have been manufacturing common brick, but at present only one, that of the Broadview Brick Company, is in sufficient repair to operate. The product is a good grade of common buff brick. This plant was not working during 1916-17.

At Pilot Butte, east of Regina, the Pilot Butte Brick Company have a small soft-mud brick plant making a rather low grade of common brick from clay found in irregular pockets in a glacial outwash plain. The plant was operated during part of 1916.

At times in the past small local brick yards have been in operation at Balcarres; Moosejaw; in the Qu'Appelle valley north of Indian Head; and at Wolseley.

Sewerpipe or stoneware clay is being shipped outside the Province to Medicine Hat, for the manufacture of sewerpipe, sewer block, flue lining, wall coping, and stoneware pottery. No plant for the manufacture of these wares has yet been established in Saskatchewan. A report on the Mineral Production of Canada published annually by the Mines Branch includes details and statistics of the clay products industry for each province.

RAILWAYS AND FUEL SUPPLY.

Until recently, rail transportation has been lacking in the most valuable clay areas. The Portal-Moosejaw branch of the Canadian Pacific railway has served the Estevan field for a number of years, but the important refractory clays do not occur there.

Just three years ago the Canadian Northern railway completed its Avonlea-Gravelburgh branch, as far as Claybank in the Dirt hills, and made the high grade clays of this locality available. However, the market for high class face brick broke about the time the railway was laid down, and the plant at Claybank suffered accordingly. During the past two years the same Canadian Northern railway branch has been constructed farther west, and made available the clays of the north end of Lake-of-the-Rivers, near Mitchellton.

Four years ago the Canadian Pacific railway started its Weyburn-Stirling line; and since then has tapped the clays of the south end of Lake of-the-Rivers and of the Frenchman River valley. The line is now completed as far west as the Alberta boundary, and it is hoped that the time is not far distant when connexion will be made with the construction ea from Stirling, Alberta.

South of the Canadian Pacific railway the Canadian Northern Railway Company has a branch line extending westward to near the southeast end of Willowbunch lake. If this line is completed along the proposed route, it will open up the clay and lignite areas immediately to the north of Wood mountain.

At present, most of the fuel used is brought by rail over the main line of the Canadian Pacific railway from Alberta. It is mostly a semibituminous coal, and, because of the long haul, the price is high. In the Estevan field a certain amount of the local lignite is utilized, but its full efficiency is not being realized.

Extensive tests[1] carried on at the Fuel Testing plant of the Mines Branch, Department of Mines, Ottawa, have shown that the lignites are ideal for making producer gas for power generation in a gas engine. No steaming tests have been made, but the analysis points to its successful application in this way under suitable mechanical conditions.

Lignite of the same age as that at Estevan is being used with decided success in the plant of the Hebron Fire and Face Brick Co., Hebron, North Dakota. The gas is used in a large Richardson continuous kiln, burning fireclay face brick to cone 6 down. No difficulty is experienced in getting this temperature in the kiln, with gas; whereas, very heavy firing and careful attention is necessary to attain the temperature of cone 3 in the down-draft kilns when using lignite direct.

Recent development in methods of firing intermittent kilns with gas, indicate that it is a great saving in fuel and kiln expense. The so-called Underwood system has been installed in a number of American plants, and is worthy of investigation.

The gas producer has come to the clayworking industry to stay, and the clayworkers of Saskatchewan, and the west generally, should not be slow to adopt it as an economical means of converting a poor fuel to a high-grade one.

Natural gas has not been struck, as yet, in commercial quantities anywhere in the southern part of the Province. Preparations are being made to sink a well at Eastend, in the hope of getting a cheap fuel to aid in the local development of the clays.

Gas Producer Tests on Souris Coal.[2]

	1.	2.
Volatile matter	32·8%	43·3%
Ash	7·2%	11·1%
Moisture	23·3%	13·4%
Cal. value of coal as charged B.Th.U	8,300	9,374
Cal. value of gas (lower) per cu. ft. B.Th.U	112·7	117·4
Producer efficiency	0·578	0·488
Coal per B.H.P per hour, lbs	2·28	2·48
Average interval between poking	5 hrs.	6 hrs.
Clinker	very slight	none
Tar	none	Gas washer not used, no tar.
Uniformity in gas quality	very uniform	very uniform
Amount of steam used	very little	none
Combustible in refuse	not analysed	moderate
Remarks	very suitable fuel for producer, easily worked	very suitable for producer, easy to work, no trouble

[1]B. F. Haanel; Report No. 299, Mines Branch.

[2]Tests on lignite coal from Taylorton, Sask., Mines Branch, Department of Mines, Ottawa, Rept. No. 83, Vol. 11, p. 111.

PLATE II

Substantial type of prairie school house built of brick.

PLATE III

Substantial type of prairie farm house, built of brick, Bayard, Sask.

THE FUTURE OF THE CLAY INDUSTRY.

The importance to the whole Canadian west, of the clay resources of southern Saskatchewan, cannot be overestimated. There is an abundance of high grade clays suitable for the manufacture of stoneware, Rockingham ware, and white earthenware. The fireclays of the eastern section will make a No. 2 grade of refractory, while the more plastic clays should find a use as bond-clays in the making of retorts and other special refractory shapes. They are also adapted to the manufacture of architectural terra-cotta, paving brick, face brick, and all varieties of burned clay products for structural purposes.

Before the outbreak of the war in Europe, the immediate future of the clay industry in Saskatchewan promised well. The railways were spreading lines of transportation over the country, crops were fair, and the western farmer was beginning to appreciate something better than a sod shack to live in. Lumber had to be hauled great distances and the price was accordingly high. Prairie fires were teaching the builders with wood the value of more fireproof construction. Altogether, the country was ripe for a better supply of burned clay products.

With the war, needs have not materially changed. Business is simply marking time for a better monetary condition. The country is essentially a farming one, and with wild boom days over, and the war at an end, normal conditions should soon return.

GENERAL GEOLOGY.[1]

The geological history of southern Saskatchewan is essentially that of the great plains of which it forms an important part. Throughout the Palæozoic and Mesozoic eras it was an area of alternate elevations and depressions, during which the sea was admitted, and great thicknesses of sediment were laid down. Partial evidence for this is to be found on the plains, as the oldest rocks there, namely, the Pierre shales, are Upper Cretaceous. In passing eastward towards the Pre-Cambrian rocks of Manitoba, across the great plains, a series of Mesozoic and Palæozoic sediments, with gentle westward dips, are met with; and drill holes put down at various points in Manitoba and Saskatchewan, have shown that these extend westward under the areas now occupied by the Upper Cretaceous, Tertiary, and Quaternary sediments.

None of the elevations or depressions were extensive enough to cause dislocation of the strata in the great plains area, but were rather in the form of broad, gentle, uplifts and sinkings of continental extent. The sediments remained, approximately, flat-lying, and only one minor case of faulting has been recorded. McConnell[2] describes a small area covering township 1, range 27, west of 3rd. meridian, near the international boundary.

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[1] Main outlines after Rose, G.S.C. Memoir 89.

[2] McConnell, Ann. Report of G.S.C., Vol. 1. 1885. p. 42C.

The periods of erosion, which were marked by the intervals in the succession of the strata when the area must have been above sea-level, did not leave any great unconformities between the strata of the different ages, except between the Tertiary and the Quaternary.

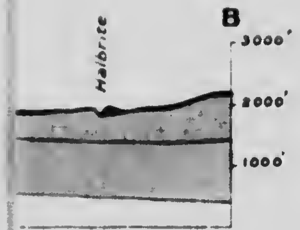
Cretaceous Period.

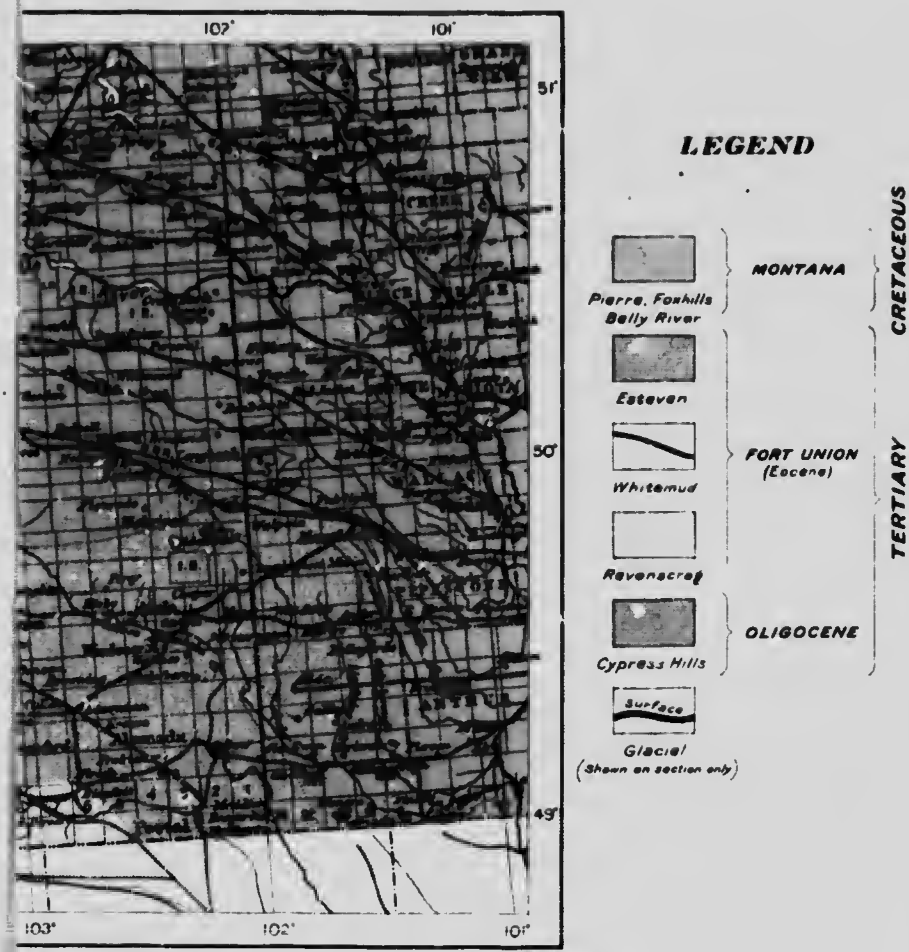
PIERRE FORMATION. (SHALE).

The upper Cretaceous sediments are the oldest known in southern Saskatchewan, and are represented by the Pierre shale and Fox Hills sandstone of the marine Montana stage. During this stage the whole of the interior of the continent was depressed, and occupied by the sea. In the waters of this sea great thicknesses of clay were deposited, represented by the Pierre shale of the area. Towards the latter part of the existence of this sea, there were fluctuations in the depth of the water and a tendency to shallowing, with consequent variation in deposition; the character of the material laid down in the eastern part of the basin differing somewhat from that deposited in the west. This state of fluctuation gradually gave place to the shallow water shore conditions which prevailed during the deposition of the succeeding Fox Hills sands.

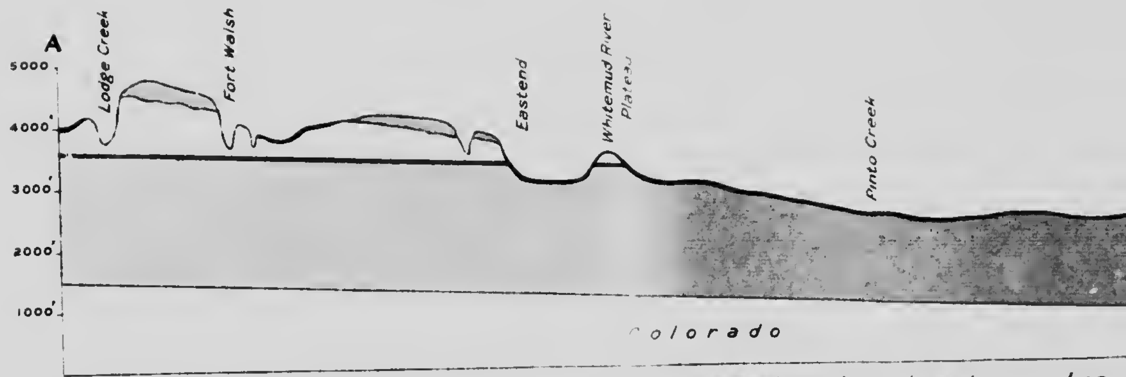
The most important beds of the Pierre formation from the clayworker's standpoint are found outcropping in the Qu'Appelle valley near Tantallon station on the Canadian Pacific railway. For a few miles east and west of this station, and south up a tributary coulee, the upper hundred feet of the valley sides consist of a hard, grey shale, referred to the Odanah horizon. This is underlain by soft unconsolidated shale of a chocolate-brown colour, which weathers to a very sticky claylike gumbo, and may be referred to the Millwood. Similar shale outcrops in the Assiniboine valley near Virden, Manitoba, and in the upper part of Turtle mountain. The Odanah is not known to outcrop west of the Tantallon district; but other beds of the Pierre shale are found in the deeper river valleys west to the Alberta boundary. Contacts of the Pierre with younger formations in the Dirt Hills, Wood Mountain, and Cypress Hills districts, do not show the Odanah. It does not appear to have been laid down west of the general line of the Saskatchewan-Manitoba boundary. In all the area west of this the Pierre consists of dark grey, clay shale: sometimes sandy towards the top, but always weathering to a very sticky gumbo clay of little value to the clay-working industry. It was sampled at numerous points, and found, in every case, to have an excessive shrinkage in drying and burning, as well as giving a dirty scum on the burned material.

The following list gives a number of localities where the Pierre shale has been sampled and tested:—





Geology compiled from Map No. 55A
G. S. C. with minor geological additions
by N. B. Davis, 1916.



General geological section on line

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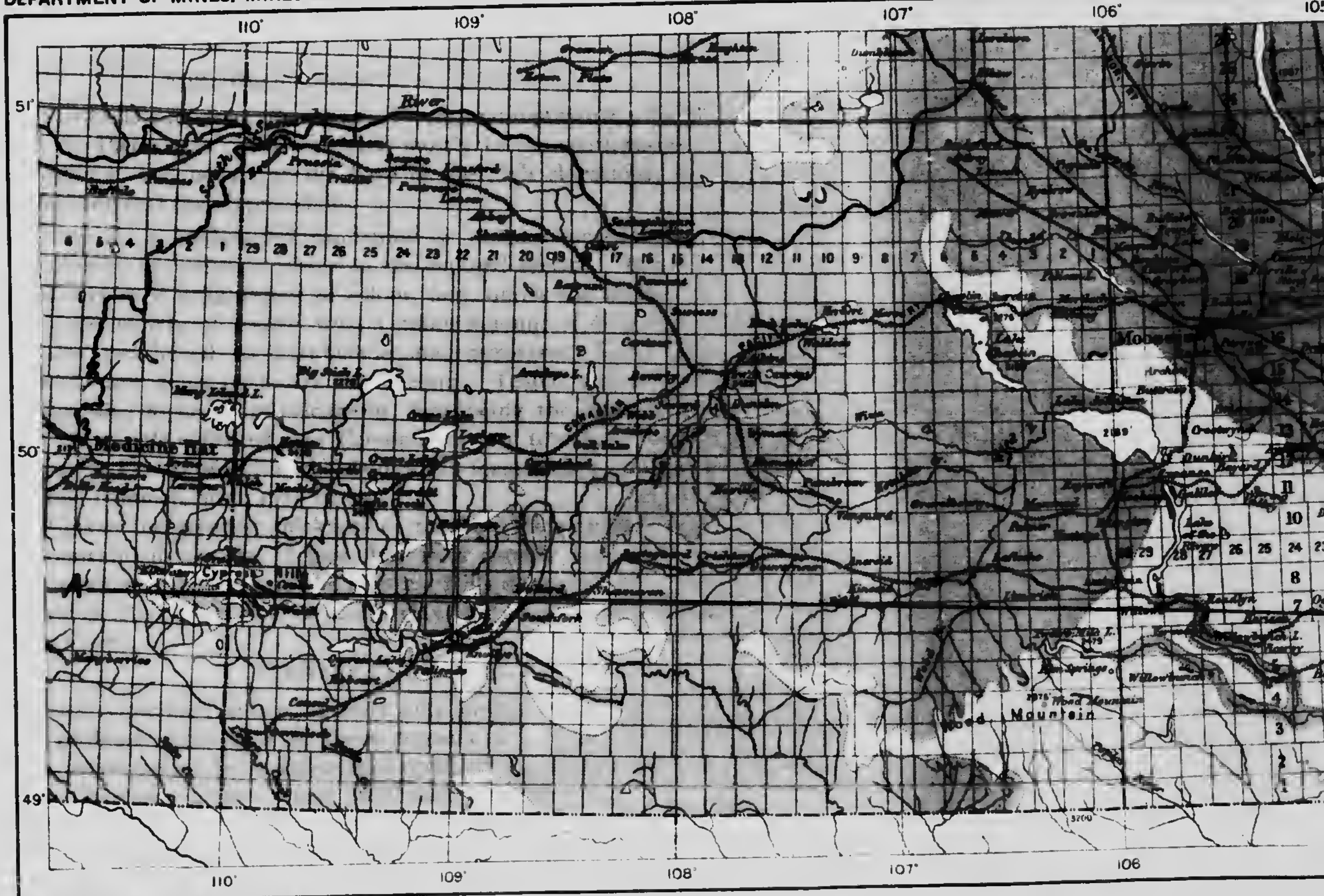
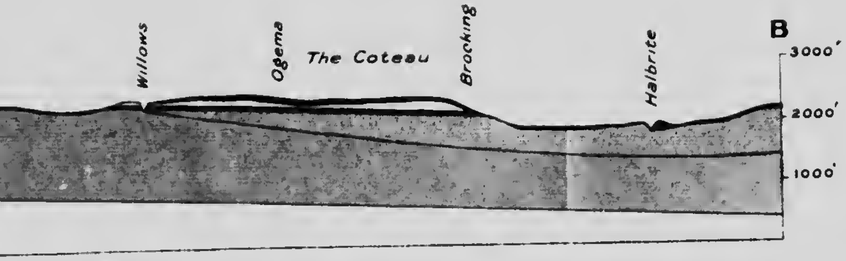


Base map from plates, Dept. of the Interior
H. F. Baine. *Chief Draughtsman.*

General geological map of Souther

SCALE: 35 MILES TO 1 INCH



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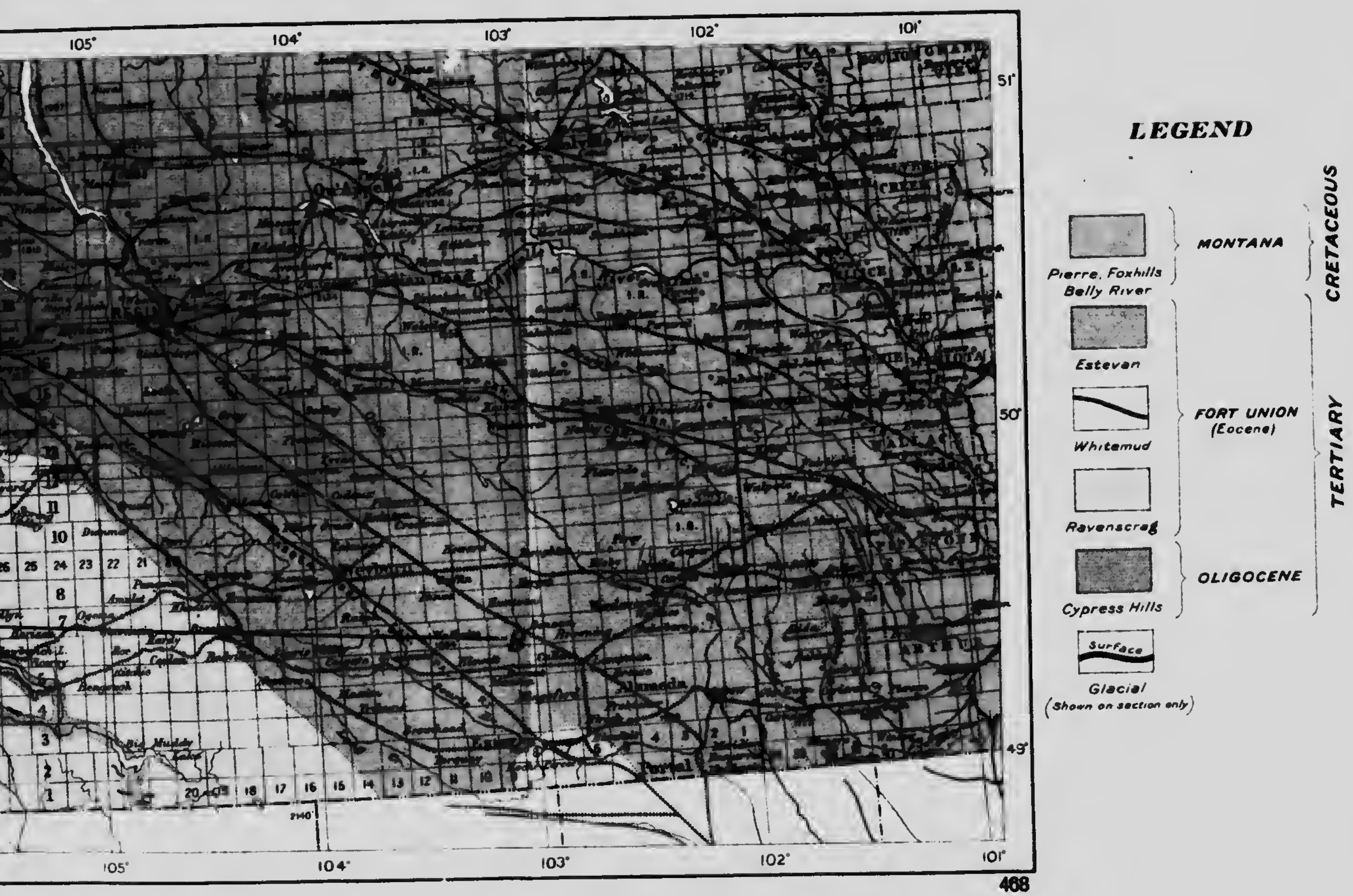

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Geology compiled from Map No. 55A
G. S. C. with minor geological additions
by N. B. Davis, 1916.

Elbow,
Old Fort Walsh,
Ravenscrag,
Regina beach,
Rocky creek,
Seward,
Swift Current,
Tilney,
Willows.

Wherever examined, the Pierre, other than the Odanah and Millwood, was found to contain crystals of gypsum or selenite, and concretionary iron masses of various sizes. The weathered surfaces of the exposures are often whitened by crystals of soluble salts, brought to the surface by the moisture drying out.

FOX HILLS FORMATION. (SAND).

The Fox Hills sandstone succeeds the Pierre, and represents a shallowing period of the Pierre sea. It is restricted mostly to the southwestern part of the Province, and occurs at the base of the high elevations, such as Wood mountain and the Cypress hills.

The rock is a fine-grained sandstone or unconsolidated sand, and usually yellow to brownish in colour on the exposed surface. Beneath the weathered surface it is light grey in colour, and, under the microscope, is seen to consist mainly of quartz, with a minor amount of dark green and black grains recognized as hornblende and pyroxene. Some feldspar and the white and black micas are also present. Tested with acid, it was found, generally, to be quite calcareous, lime being the chief cementing material. A sample collected near Eastend burned to a light red colour, at 1750 degrees F. By selecting the sand of this formation, a good material for moulding common brick may be had.

Rose[1] gives the greatest thickness of the Fox Hills sandstone in the Wood Mountain district as 75 feet, but it is usually less. McConnell gives the maximum thickness in the Cypress Hills district as 150 feet, but a large part of it is clayey sand or sandy clay, and may be only the sandy top of the Pierre.

TERTIARY PERIOD.

The sand described above, appears only in the western part of the area, and probably represents the shore deposits of a Pierre sea retreating westward, accompanied by a differential uplift of the country to the east of an axis passing northeast and southwest through Wood mountain. The country to the east of this was occupied by fresh water lakes and swamps in which sands, silts, clays, and lignites, were deposited.

[1]B. Rose, G.S.C. Memoir 89, p. 31.

This change from marine to fresh water conditions marks the end of the Mesozoic era and the beginning of the Tertiary. The change was slow and gradual, and a Tertiary flora developed on land; while the water life was still influenced by Cretaceous types. Remains of land reptiles of Mesozoic type are reported by Dawson[1] in beds to the south of Wood mountain along Rocky creek, and these beds have been referred by Rose[2] to the Lance formation. This is the only part of the area in which Lance beds have been described as occurring. Formerly, they were included in the old Laramie by Dawson and McConnell. They are here included in the Estevan beds of the Fort Union.

EOCENE OR FORT UNION FORMATION.

Up to the present, the Fort Union formation has not been subdivided, although the necessity for doing this was recognized by McConnell and Dawson[3] in the early reports on the area. McConnell states that the Laramie (Fort Union):—

May be separated lithologically over most of the district into two distinct divisions. The lower one, which succeeds the Fox Hill conformably wherever the contact plane of the two formations was observed, bears a strong resemblance to the upper part of the Belly River series, and consists of about 150 feet of feebly coherent, greyish and pure white clays, sandy clays, and sands, with occasional beds of carbonaceous shales and lignite. A small bed of black clay was also found to be pretty widely distributed. The beds of pure white sands and clays form the most distinctive feature of this band, and were observed, with few exceptions, wherever the base of the formation was exposed. In the badlands south of Wood mountain this division consists almost exclusively of clay. The upper division is more arenaceous, and is predominately yellowish in colour. It has a maximum thickness in the district of 750 feet, and is composed of sands passing into soft sandstone, silts, and clays, and also holds a few beds of hard sandstone, part of which is of nodular character, together with some carbonaceous shales and lignite.

Leonard[4] describes the western half of the state of North Dakota to be underlain by strata which have been referred to the Laramie, but undoubtedly some of them are Tertiary in age (Fort Union).

Just where the dividing line between the Laramie and Tertiary occurs is doubtful and can only be determined by paleontological evidence. But lithologically the so-called Laramie formation may be divided into three parts. At the bottom is a great series of beds consisting of impure, low grade clays, sands, many of them calcareous, and lignites. Above, there is a horizon not more than 150 feet thick in which occur the high grade, light burning, more refractory clays, although some of these are highly calcareous and fuse at very low temperatures. Overlying these clays are some 300 to 400 feet of sand, part of which is cemented by a calcareous cement.

In the Cypress Hills area the white clay beds rest directly on the Pierre and Fox hills, and are overlain by the yellow clays, silts, and sands.

In the Big Muddy valley, the white clay beds are separated from the Cretaceous by a considerable thickness of dark grey clays, sands, silts,

[1]Dawson, Geology and Resources of the 49th. Parallel, 1875, p. 103.
[2]Rose, Memoir 89, G.S.C. p. 38.
[3]McConnell, Ann. Rep. G.S.C. Vol. 1, 1885, p. 67-68C. Dawson, Geol. and Resources of the 49th. Parallel, 1875, p. 103.
[4]Leonard, State Geol. Surv., N. Dakota, 4th. Biennial Rep., p. 108.

and lignites (see Plate X). They are overlain by the same yellow beds as in the Cypress hills.

In the Souris valley the middle and lower divisions are present near Halbrite and what appears to be the upper and lower divisions minus the middle division at Estevan.

Whether these lower beds belong to the Lance formation has yet to be definitely established, but in the meantime they can at least be separated from the other beds of the Fort Union on a lithological basis. To this end the following new names are proposed, using names of type localities:—

$$\begin{matrix}\text{Eocene} \\ \text{Fort Union}\end{matrix}\left\{\begin{matrix}\text{Ravenscrag beds,} \\ \text{Whitemud beds,} \\ \text{Estevan beds.}\end{matrix}\right.$$

Estevan Beds.

Beds of the Estevan group are exposed in the Souris valley from Halbrite to Estevan; in the Big Muddy valley from the international boundary to the forks; in the Dirt hills at Claybank, and south of Wood mountain. They do not occur in the Frenchman River plateau, Swift Current Creek plateau, or in the Cypress hills.

In general the beds are fairly uniform in appearance, but the individual beds are seldom continuous for any distance; they thicken and thin from place to place. The colours are commonly grey to dark grey on fresh exposures, but weather to yellowish grey and light grey on exposure. They have a very high content of colloidal matter and vegetation has difficulty taking root on the exposures. As a result the outcrops are often weathered to badland topography. None of the beds are hardened to any extent, except an occasional sand bed.

The Estevan group contains clay beds that are of doubtful value to the clay worker. They are inclined to be stiff and sticky in their working qualities, and, when moulded in the stiff-mud way they have excessive shrinkage which causes cracking in the drying process. Even when moulded by the dry-press process they have an excessive shrinkage in burning, a defect which requires special treatment of the raw material and adds to the cost of making brick. One of these beds is being worked and specially treated at Estevan for making red dry-press face brick.

The Estevan beds are of the greatest importance because of the presence of many workable beds of lignite coal.

Whitemud Beds.

The upper part of the Fort Union is distinctly separated from the Estevan beds by a layer of refractory white clays which persist in Canada east and west from the Souris valley to the Alberta boundary, and north and south from the international boundary to the escarpment west of

Elbow. These clays are relatively pure and refractory, in striking contrast to the impure clays and sands above and below.

The relation of the white band clays to the underlying formation changes somewhat from west to east. In the Frenchman River valley near Eastend the white clays appear in contact with the Pierre and Fox Hills, but going east to the Wood Mountain country, particularly along the Big Muddy valley, a dark grey lignite bearing series, the Estevan beds, appears below the white band and continues towards the Manitoba boundary. In the Souris valley near Halbrite, and farther north near Yellow Grass, there are small outliers of the white band on top of the lignite bearing Estevan beds.

Although no definite unconformity has been recognized between the different groups here classed as Fort Union, there is reason to believe that the white clays represent a time interval during which a complete change in drainage took place. The Estevan beds represent the waste from such impure rock formations as the Pierre shale and Palæozoic rocks, while the white refractory sands and clay represent the waste from the weathering of granitic rocks similar to the Pre-Cambrian of Manitoba to the east. The physical characters of the clays of the white band suggest that the source of the material was from the east. Those beds found in the Souris valley near Halbrite and Yellow Grass, in the Dirt hills at Claybank and Mitchellton, and in the Lake-of-the-Rivers valley near Willows, are decidedly more refractory and pure than those to the west in the Cypress Hills district. It is to be expected that the nearer the source the purer and more refractory will be the material. The eastern beds are true fireclays, while those of the west are semi-refractory and stoneware clays.

This group contains the most valuable clay resources of the Province. Considerable quantities of clay from Willows and Eastend are being shipped to Medicine Hat for the manufacture of sewerpipe, wall coping, flue lining, and stoneware pottery. Firebrick and high grade face brick are being made from the clays at Claybank.

Ravenscrag Beds.

The principal formation of the higher elevations of the area is the upper part, or Ravenscrag beds, of the Fort Union. It appears over the white band in all the elevations east as far as the Coteau. In the northern part of the Souris valley it has been completely removed by erosion, but near the boundary at Roche Percée it appears overlying the Estevan horizon to a depth of about one hundred feet.

It consists of grey and yellow clays, silts, and sands with many workable beds of lignite. The following section, measured by McConnell,[1] at

[1]McConnell, Ann. Rep. G.S.C. Vol. I, 1885, p. 28C.

the junction of Concrete coulée with the Frenchman River valley, near Ravenscrag, is illustrated in the frontispiece.

Top 1.	Yellowish very fine-grained clays passing into pure clays and sands	110 feet.
2.	Greyish clays, carbonaceous shales, and thin beds of lignite, yellowish sands, clays, and sandy clays	120 "
3.	Greyish shales	6 "
4.	Carbonaceous shales	4 "
5.	Lignites	3 "
6.	Greyish shales	30 "
7.	Brown carbonaceous shales	6 "
8.	Greys and almost pure white sand and clays	50 "
9.	Coarse rusty sands (Fox Hills)	125 "
10.	Lead grey and dark shales (Pierre)	50 "

The upper seven beds of this section are referred to the Ravenscrag division of the Fort Union. Number 8 is the Whitemud division. The Estevan beds are entirely absent. Number 9 is the Fox Hills sandstone.

The Ravenscrag division contains beds of red and buff burning clays that are of value to the clay industry, mainly for the manufacture of common brick and fire proofing. Buff burning beds are being used at Estevan and Shand for making wire-cut brick.

OLIGOCENE.

Cypress Hills Beds.

An erosion interval followed the deposition of the Fort Union, and in Oligocene time a great fan of gravels, sands, silts, and clays was spread eastward from the Rocky mountains. At present these beds cap all the higher elevations of the western plateaus, extending from the west end of the Cypress hills to the east end of Swift Current Creek plateau, a distance of about 140 miles. They are unconformable to the beds below, and in their western extension rest on the Fort Union. East of Eastend coulée they overlap the Fort Union and continuing eastward are underlain by the Fox Hills sandstone and Pierre shale.

The Oligocene beds of the Cypress hills are largely represented by a thick bed of quartzite pebbles apparently derived from the quartzite formations of the Rocky mountains. The pebbles vary in size from an inch up to seven or eight inches in diameter, and in places are cemented by a calcareous cement. The greatest thickness and coarsest pebbles are found in the western part of the area.

The beds of Swift Current Creek plateau consist mainly of calcareous clays and silts, and quartz sands, associated with beds of fine quartzite gravel. Unlike the underlying marine beds .. tne Pierre they are seldom continuous from place to place.

The outcrop of Oligocene clays near Neville, south of Swift Current, has some interest to the clayworker, while the quartzite gravels of the Cypress hills should interest those using grinding pebbles.

The Pliocene followed as a long period of erosion and base levelling, to form the approximate surface of the great plains on the Cretaceous, and leaving isolated plateaus of the Tertiary.

Quaternary Period.

PLEISTOCENE FORMATION.

The Tertiary period ended with a change from a very temperate to a frigid climate, and during the Quaternary period the whole area was overridden by a continental glacier. The effect of the moving ice sheet over the soft and flat lying formations was not very great from the standpoint of erosion, and hence the main surface features developed in Pliocene time were changed very little. This was particularly true of the southern part of the area, but modified, somewhat, to the north. The thick deposits of glacial material shown in the deep trenches of the present Saskatchewan and Qu'Appelle valleys (400 feet) indicate considerable filling over the Pliocene topography.

The most southerly extent of the ice sheet was not very far south of the international boundary, and consequently the southwestern part of the area was very thinly covered by drift, wide areas being practically free of it.

No evidence of overlapping by ice advancing from both the northeast and northwest has been observed, the whole movement having apparently been from the northeast.

The maximum thickness of the ice mass in the vicinity of the Cypress hills is estimated by McConnell[1] as 2,000 feet. The top of the western part of the Cypress hills was entirely unglaciated and must have formed an island in the glacial sea. No drift or sign of glacial action is found above an elevation of 4,000 feet above sea-level.

The retreat of the ice cap, with the attending deposition of boulder clay, sands, silts, and lake clays, was the most important phase. At the end of the first stage of the final retreat from the area the ice stood to the north of the Cypress hills, Swift Current Creek plateau, and the general line of Pinto Horse butte to Wood mountain. Glacial streams poured their waters to the south and deepened the Pliocene channels of the Frenchman River valley and its tributary streams flowing south.

A further retreat of the ice front to the Coteau, and a line swinging in a wide circle to the north of Swift Current, dammed large lakes against the

[1]McConnell. Ann. Rep. G.S.C., Vol. 1. 1885.

Cypress hills to the south, which probably had their overflow through Medicine Lodge coulee. A large lake or series of lakes, to the north of Wood mountain, probably drained through Twelve Mile Lake valley to the Big Muddy outlet.

With a further retreat to the northeast the ice front halted for a considerable period, judging by the great thickness and width of the moraine system along the Coteau. At this stage a large lake occupied the basins of Lakes Johnston and Chaplin and probably extended some distance westward over the country at present drained by the Wood river. The outflow from this lake went by way of Lake-of-the-Rivers valley to the Big Muddy.

In the northwestern part of the area many small glacial lakes were formed, and at least one large one in the vicinity of Lancer.

The next stage marked a retreat to a N.W. and S.E. line passing through Moose mountain, and the damming of a large body of water glacial Lake Regina, to the east of the Coteau in a basin extending in a N.W. and S.E. direction from Weyburn to the Qu'Appelle north of Regina. In the depression now occupied by the South Saskatchewan river a series of lakes formed and outflowed to Lake Regina near Caron. As the ice front continued to retreat these found an outlet down the Qu'Appelle depression. A further retreat to the northeast was marked by wide low moraines and numerous intermorainal lakes and outwash plains in which clays, sands, and gravels were laid down.

This glacial distribution of clays, sands, and gravels has been of great importance to the area. The large glacial lake bottoms form the most important grain growing belts, but have little value to the clayworker because of defects of the clays in drying and burning. The clays of the smaller glacial lake bottoms, particularly in the northeastern part of the area in the outwash basins where the clays are calcareous and silty, are being used for making common brick. In the northwestern part of the area the silty clays of the extinct lake near Lancer are also an important resource for this purpose.

The sands, gravels and boulder moraines are of value for building construction and form a potential resource for building good roads.

RECENT FORMATION.

With the complete retreat of the ice from the continent there was a return to a temperate climate, followed by semi-arid conditions. The deep valleys, cut by the large rivers outflowing from the melting ice front, continued to be water courses, but of streams of greatly diminished size. Some of these streams have a free outflow while others drain to local saline lakes.

The valleys, with outflowing fresh water streams such as the Frenchman, the Qu'Appelle, and the Souris, have been deeply silted up by the inwash of material from the valley sides. Their wide, flat bottoms contain deposits of clay silts that are of value for the manufacture of common brick.

The valley of the Big Muddy, and its two branches to Twelve Mile lake and Johnston lake, has also been silted in like those described above, but there has been no through drainage, the runoff going to saline lakes within the valleys. Consequently there has been a concentration of the soluble salts of the surrounding country into the valley, and the clay silts of the valley bottom have been rendered useless to the clayworker because of intense scumming and drying defects.

Because of the semi-arid climate, whereby the absorption and evaporation about equal the rainfall, surface weathering has not extended to any depth and cannot be depended on to supply red-burning surface clay as in Ontario. Often, where the material is red-burning, the evaporation has concentrated soluble salts in the top foot or two, and these obscure the red colour in the burnt brick by the formation of a white scum on their surfaces.

GENERAL TECHNOLOGY.

CLASSIFICATION OF SASKATCHEWAN CLAYS.

In a general way clays may be classified according to their geological occurrence and the uses to which they are adapted. From a geological standpoint clays are either residual or transported. Residual clays are formed by the weathering of rock in place, while, on the other hand, transported clays are those that have been transported from their source by water and deposited elsewhere. All the clays of southern Saskatchewan are of the transported type and hence residual clays need not be considered.

Considering the uses to which clays may be adapted, they may be classified as refractory, semi-refractory and non-refractory. Refractory transported clays constitute the majority of the fireclays and ball clays of commerce, and to this group belong many of the Whitemud beds of the Dirt hills and Lake-of-the-Rivers districts, as well as the top bed in the vicinity of Eastend.

Fireclays are used most commonly in the industrial furnaces of the ceramic and metallurgical industries, such as blast, open-hearth, and crucible melting furnaces, Bessemer converters, glass furnaces, lime and cement kilns, for flues, boiler settings, stove linings, etc.

Clays in the refractory group do not deform, in the standard cone deformation test, until the temperature of 26 is reached. Those that deform at temperature between cones 26 and 30 inclusive are classed as No. 3 grade; those that deform at temperatures between cone 30 and 33 inclusive are of No. 2 grade; while those that deform above cone 33 are considered No. 1 grade.

This classification of refractories is more or less that proposed by the U. S. Bureau of Standards.[1]

[1]Bleininger and Brown. Tech. Paper No. 7, U.S. Bureau of Standards (Cone 28 to 30 suggested as No. 3 range.)

Certain fireclays are non-plastic and because of this are called flint clays. A thin bed of flint clay occurs in the fireclay beds near Dickenson, North Dakota, but it was not found in Saskatchewan.

Many of the fireclay deposits of the world occur underlying coal seams, but such is not the case in Saskatchewan. The clays under the thickest seams of coal, such as in the Estevan district, are non-refractory. The fireclays of the Whitemud beds are not directly associated with any well defined coal seams.

Clays that are very plastic, refractory, and white burning are called ball clays. They find a use as a plastic ingredient of white ware bodies to give working strength. The clays of the upper part of the Whitemud beds at Willows are good enough to be classed as ball clays. An analysis of a sample collected in the pit of the Alberta Clay Products Company at Willows is given in the following table, in comparison with standard ball clays:—

	I.	II.	III.	IV.
SiO_2	58·28	48·99	45·57	46·11
Al_2O_3	26·07	32·11	38·87	39·55
Fe_2O_3 / FeO	1·79	2·34	1·14	0·35
CaO	0·68	0·43	....	....
MgO	0·34	0·22	0·11	0·13
K_2O / Na_2O	1·46	3·31	0·16	....
TiO_2	....	....	1·30	1·20
H_2O	12·02	9·63	14·10	13·78
Total shrinkage at cone 9	17·0	....	20·0	15·0

I. Willows clay: 474.
II. English ball clay.
III. New Jersey ball clay.
IV. Florida ball clay.

The clays from the following localities were found to be sufficiently refractory to be classed as fireclays:—

Sample No.	Locality.	Refractory value.	Thickness.
436	Sec. 36, 6, 22, 3rd	Cone 26	6 ft. bed.
474	Willows	" 30	15 ft. bed.
476	"	" 28	19½ ft. Same section.
477	"	" 27	
478W	"	" 30	
469	"	" 30	24 ft. Same section.
467	"	" 31	
470	"	" 29	
471	"	" 30	
481	Sec. 14, tp. 11, r. 28, 2nd	" 28	12 ft.
1648	Claybank	" 32	15 ft. + Same section.
1649	"	" 31	
1650	"	" 32	....
486	Sec. 11, tp. 13, r. 26, 2nd	" 28	4 ft. bed.
565	Yellow Grass	" 28	10 + ft. bed.
556	Halbrite	" 27	6 ft. bed.
551	Sec. 17, tp. 21, r. 10, w. of 3rd	" 26	20 ft. bed.

The Saskatchewan fireclays are all distinctly soft and usually very plastic. They differ from the hard gritty fireclays or shales such as those occurring in Sumas mountain, B.C., inasmuch as they require the addition of a non-plastic ingredient in order to reduce the shrinkage and assist in the drying of wares made by the plastic processes. The absence of a suitable non-plastic material has led to the adoption of the dry pressed process in the manufacture of firebrick from these clays.

Clays that deform below cone 26 to as low as cone 10 are classed as semi-refractory. Some of the more refractory grades are good enough for certain moderate fire resisting purposes such as stove brick and ladle linings, but the majority are used for making sewerpipe, stoneware, art pottery, paving brick, architectural terra-cotta and face brick.

Stoneware and sewerpipe clays must have good plastic and drying qualities, and must burn to vitrified bodies between the temperatures of cone 3 to 9. They must also take a good salt glaze. Most stoneware is made from a mixture of clays to produce a body having the required properties in the raw and burned state.

The clays of the Whitemud beds of the Frenchman River valley, near Eastend, are mainly of stoneware grade. They are being mined and shipped to Medicine Hat for use in the manufacture of sewerpipe in the plant of the Alberta Clay Products Company, and for stoneware pottery in the plant of the Medalta Stoneware, Ltd.

Certain of the Eastend clays, particularly those described as Nos. 438, 439, 440, are well adapted to be used for modelling clays in the schools of the Province and of the adjoining provinces of Alberta and Manitoba.

All of these clays are suitable for making face brick by either the dry-press or stiff-mud process, and certain of them have possibilities for paving brick.

In the vicinity of Tantallon in the Qu'Appelle valley, the Odanah horizon of the Pierre consists of a semi-refractory red burning shale which does not deform until the temperature of cone 15. The burning qualities are such as to preclude its use for sewerpipe, but it makes a beautiful red face brick by either the stiff-mud or dry-press process.

The clays of the non-refractory class are common to the Pierre, Estevan, Ravenscrag, Oligocene, and Glacial (Pleistocene) formations, and include materials suitable for making face brick, common brick, fire proofing, and field drain tile. Six of the seven clayworking plants in the area are working clays of this class.

METHODS OF MANUFACTURING.

The manufacture of brick, fire proofing, and drain tile is more or less standardized, but the details of handling any given clay or shale varies with the physical properties of the material and the use to which the manufactured article is to be put.

Mining.

The mining or winning of the workable clays of Saskatchewan is a comparatively simple matter, because of the open nature of the exposures in coulée sides easy of access. They are nearly all workable by the open pit method. Even the high grade refractory clays are so well exposed that underground mining will not be necessary for some time to come. All except the Odanah shale at Tantallon, are soft clays and for winter working have to be stored.

For breaking the clay out of the pit, blasting and undercutting methods are used, and the clay hauled to the plant by means of horse and cart or dump cars on a wire cable.

The methods of underground mining do not differ materially from those used in the lignite mines of the Province.

Preparation.

The preparation of the clay consists in breaking it down to allow the efficient addition of water, so that it can be moulded into shape by the particular process employed. If grog, in the form of sand or burnt clay, is necessary it is added in the machine which breaks the clay down. For the plastic process the hard shales require to be crushed and pulverized to develop maximum plasticity. This breaking down process is accomplished in two ways, with rolls and dry pan.

The roll is the simplest and most commonly used machine for reducing clays. It consists of two cylinders or cones whose surfaces revolve close together, usually one cylinder smaller than the other, and revolving at a much higher rate. This arrangement tends to throw out large pebbles and crush small pebbles when working on stony glacial clays.

The dry pan consists of a heavy vertical revolving circular pan supported on a vertical shaft and driven by gears at the top of the frame. The pan supports two heavy wheels or mullers which are mounted on a horizontal shaft. These turn as the pan revolves, and so crush the material. The bottom of the pan is solid under the mullers, but is perforated near the circumference. Two scrapers, placed in front of the mullers, throw the oversize material in front of the crushers.

For the manufacture of dry-press brick the proper water content is adjusted in the dry pan, or the clay is steamed as it comes from the screens. The roughly screened material falls into a receptacle under the pan and is elevated to screens 12 to 16 mesh, the oversize from these screens being returned to the pan.

For stiff-mud brick the clay from the dry pan goes to the tempering machine.

Tempering

The clay from the crushing machine is tempered to the proper plasticity with water in a pug mill, or in the case of soft-mud brick it often goes direct to the moulding machine. The pug mill consists of a semi-cylindrical trough in which a shaft, carrying knives, revolves. The knives are set at an angle to force the kneaded clay towards the discharge end.

Wet pans, constructed similar to dry pans, except that the bottom is solid and not perforated, are also used for tempering clay, usually that used for making high grade ware or for tempering shales of low plasticity.

Moulding.

The tempered clay is moulded into ware by three processes, depending on the conditions. The soft-mud process requires the greatest amount of tempering water and the clay in the form of a soft-mud is moulded in wooden moulds sanded on its five sides. Soft-mud brick can be made by hand but are usually made by machine. This consists of an upright box of wood or iron containing a vertical shaft set with blades as in the pug mill. At the bottom of the shaft there is a curved arm set to force the clay into the mould box. A vertical plunger forces the clay into the mould and the mould is automatically pushed out of the front of the machine on to a delivery table, while a freshly sanded mould is fed in at the side of the machine. The excess clay at the top open end of the mould is struck off with a knife by hand or by an automatic device and the brick dumped on a board or pallet to be taken to the drying racks.

This process is commonly used for working sandy clays or clays suitable for common brick. Firebrick are also made by this process, and re-pressed when leather dry.

In making ware by the stiff-mud process the clay must have good plastic and drying qualities. Less water is used in tempering than in the soft-mud process and the clay is in the condition of a stiff mud. It is fed to a machine from the pug mill and forced through a die in a continuous stream and cut into the required lengths.

Stiff-mud machines are of two types, the plunger and auger machines. The former are commonly used for making sewerpipe, while the latter are used in the manufacture of face and common brick, and fire proofing.

In the plunger machine the clay is fed into the barrel and the plunger advances and pushes it out through the die. The plunger then returns and the barrel is filled again. It is an intermittent process. On the other hand the auger machine works continuously. The clay is fed into a hopper and carried into the barrel from where an auger pushes it through the die. It issues in a continuous stream and passes on a conveyer to a cutting table to be shaped into pieces of the desired length. The ware is then stacked on suitable cars and sent to the drier.

In the dry-press process the clay is not wetted with more than 10 per cent of water. It is used just damp enough to retain its shape when pressed firmly in the hand.

The dry-press machine consists of a very heavy iron frame containing a press box (usually containing four moulds), two sets of plungers working vertically against the charge, and a delivery table with an automatic discharge from the die. The clay is fed by gravity from the storage bins into the charging device, which in turns fills the moulds. The upper plungers descend and press the clay into the mould, a second pressure being given by an upward movement of the lower plunger. As the upper plunger moves back into place the lower one follows and pushes the brick to the level of the delivery table where it is pushed off the die box by the advance of the charging box. The ware is taken from the press directly to the kiln.

The dry-press process has important advantages over the soft-mud and stiff-mud methods of moulding clays that are either tender in their drying qualities or are of low plasticity. The operation of drying with the consequent shrinkage is eliminated.

Many of the red-burning clays of the Province are tender in their drying properties and can be worked only by the dry-press method.

Drying.

Ware made by either the soft-mud or stiff-mud process must be thoroughly dried before being placed in the kiln. To accomplish this the methods used depend on the drying behaviour of the clay and the capacity of the plant.

Open air-drying is the usual method employed in many of the common brick yards. The ware is placed on level ground or on pallets in racks and allowed to dry slowly in the air. Tender clays require protection from excessive sun and wind to avoid too rapid drying, which is liable to crack the wares made from them.

Artificial drying is carried on in a closed drier, usually of the continuous tunnel type, heat being supplied by artificial means. The ware on cars is pushed into the drier at the cool end and is worked through to the warm end at a rate sufficient to allow complete drying. Depending on the nature of the clay and the efficiency of the drier the time required for drying varies roughly from 24 to 72 hours.

The ware from the driers is transported to the kilns and placed for burning.

Burning.

The operation of burning is the most important part of the process and requires great care and attention to eliminate waste. The ware, placed in the kiln in the air-dry condition, must be carried carefully through at least three stages, and sometimes through four. These are (1) water smoking, (2) dehydration, (3) oxidation, (4) vitrification. The change from the air-dry condition is in a general way one of increasing density, strength, and shrinkage, with consequent decreasing porosity and specific gravity. This is true for a certain temperature range for any given clay, but above this range the conditions are reversed.

Water smoking consists in driving off the uncombined water in the ware, and begins after the fires are lighted. It proceeds at a rate determined by the character of the clay and the type of kiln used. For example, the great water holding capacity of the red-burning clay used for pressed brick at Estevan requires a very long water smoking period, while the buff-burning clay used for making common wire-cut brick, with a much lower water holding capacity, requires a much shorter time for water smoking. It is usually a slow process and the temperature of the kiln must not be raised much above the boiling point until most of the water in the form of steam has been driven off.

As soon as water smoking is accomplished the second stage is entered upon and the temperature is raised slowly to drive off the chemically combined water. This occurs at a dull red heat and is practically complete at 700°C or 1,292°F.

Compounds, other than the silicates, such as the carbonates of lime and iron, sulphides and sulphates and carbonaceous materials begin to break down at this temperature and the reaction proceeds into the oxidation state. The combustible matter, sulphur, carbon, etc., is completely driven off and the iron is all changed to the ferric condition. This stage is completed at about 900°C or 1,652°F.

Here again the length of time required for complete oxidation depends on the nature of the clay and the equipment used.

These three stages are those most commonly used in burning structural materials and the time and temperature required for burning any given clay must be carefully studied in the plant.

Clay products such as sewerpipe, paving brick, stoneware, etc., are carried to a fourth stage called vitrification. During this stage the greatest change takes place. The clay particles begin to fuse on the surface, and as the temperature is slowly raised this proceeds inward until practically the whole mass is involved, the density reaches a maximum and an impervious or vitrified body is produced.

The time and temperature required to attain this result depend on the physical and chemical properties of the clay. For example, the fireclays of the Willows district require to be burned to cone 9 to produce a vitrified body, while the stoneware clays of the Eastend district vitrify between cones 5 and 7.

The kilns for burning clay ware are of two general types, updraft and downdraft.

The updraft type includes the common scove and the permanent walled case or Dutch kilns. The former is the simplest and consists of a rectangular pile of brick to be burned coated with a veneer of burnt brick two layers deep. The whole is then plastered with soft clay mortar to help to retain the heat. The Dutch kiln consists of two permanent side walls and ends left open sufficient to allow for loading and unloading. In both forms the lower courses of brick to be burned are set to make arched tunnels across the width of the kiln. The end of each tunnel is a fire box and the heat travels along the tunnel and up through the brick piled above, in this way burning the ware. This is the most wasteful method of burning and can only be applied with success to the cheapest of ware, such as common brick.

The downdraft kiln works like the reverberatory furnace of the metallurgist and may be intermittent or continuous. The walls are permanent and roofed in. They vary in shape from round to rectangular. Fire boxes are built into the walls at regular intervals, and suitable openings left for loading and unloading the kiln. Firing is carried on with coal, wood, or gas, the fire passing to the top of the kiln chamber and down through the ware to flues under the floor and leading to a stack.

The ordinary continuous kiln consists of a number of downdraft chambers arranged in a rectangle or oval form and connected with a central stack. When the first chamber is under fire, the heat from it carries on the water smoking and heating up of two or three chambers ahead. As soon as the first chamber is finished it is shut off from the chambers ahead and allowed tc he fire being directly applied to the second chamber. This is continu hamber to chamber, the cooling chambers furnishing heated air for ..ustion. The cooled chambers are unloaded of burned brick and reset for the burning process. In this way the process is continuous and there is little or no waste heat.

A recent application of the continuous principle has been made in the form of a tunnel with four or more fire boxes near the centre. The ware is loaded on cars suitably insulated, and these are pushed into the tunnel at a regular rate. The fire in the centre of the tunnel is pulled towards the loading end, making the opposite end the cooling section. This method of burni said to be very cheap and efficient, but to date it has been applied on this continent only to the burning of sanitary ware and firebrick.

Control of Temperature.

The means of controlling temperature varies somewhat from plant to plant. Some use the old rule-of-thumb method of judging the temperature by the colour of the hot kiln and have to employ men with considerable experience. On the other hand there are several mechanical methods that can be more generally used and give better control over both the kiln and the burner.

Seger cones.

These cones are small triangular pyramids of about a half inch to a side on the base and tapering to a point at the top in a length of three inches. (See Plate IV). They are composed of mixtures of clay and fluxes so graded as to giv a series of fusion points, each cone being equivalent to approximately 36°F. or 20°C. above the next one lower.

In the fire the cone softens, and when its fusion point is reached it begins to bend over until its tip touches the base. This condition is regarded as the finishing temperature for that cone.

They have been used for years by foreign manufacturers and their use is increasing on this continent. They may be obtained from Prof. E. Orton, Columbus, Ohio, or from the Mayer China Co., Beaver Falls, Pennsylvania.

The following partial table gives the approximate deforming temperatures of standard seger cones:—

No. of Cone.	Approximate Fusing Point. Degrees F.	Degrees C.
010	1,742	950
06	1,886	1,030
03	1,994	1,090
1	2,102	1,150
3	2,174	1,190
5	2,246	1,230
7	2,318	1,270
9	2,390	1,310
11	2,462	1,350
13	2,534	1,390
15	2,606	1,430
20	2,786	1,530
25	2,966	1,630
27	3,038	1,670
29	3,110	1,710
31	3,182	1,750

The following table gives the approximate cones to which the various types of ware are burnt:—

Building brick	012–01
Paving brick	01–5
Sewer-pipe	3–7
Buff face brick	3–9
Hollow blocks and fireproofing	07–1
Terra-cotta	02–7
Conduits	5–8
Firebricks	5–14
White earthenware	8-9
Red earthenware	010–05
Stoneware	6–8
Porcelain	11–13
Electrical porcelain	8–12

PLATE IV

Top row, clay test cones.
Middle row }
Bottom ro : }standard seger cones.

Veritas Firing System.

A refinement in the old method of controlling the firing by use of draw trials has resulted in the "Veritas Firing System." This system is in use in a large number of potteries and other clay plants in the United States.

In this system the draw trials consist of unburned dust pressed rings of a standard clay body measuring 2·5 inches in diameter, with a hole of 0·85 inches. The clay body has a composition approaching that of white ware. In using them a number of rings are placed at important points in the kiln and are withdrawn at different times during the burn. The diameter of the cooled ring is then measured by a simple device and the shrinkage compared with a standard shrinkage table.

These firing rings, like pyrometric cones, do not indicate definite temperatures but do show kiln conditions, and the progress of the ware during the various stages of burning.

Thermo-electric Pyrometers.

Many plants throughout the country are installing thermo-electrical pyrometers. This type of temperature measuring instrument consists of a thermo couple, two pieces of wire of different composition welded at one end connected by copper wires to a galvonometer or potentiometer. The two wires of the thermo couple have different heat conductivities, and this difference sets up an electric current through the system. The intensity of current varies with the temperature of the couple and is read on a graduated scale in the recording instrument. (Galvanometer or potentiometer.)

The thermo couple is usually encased in a protecting tube of porcelain or some refractory material and placed at an important point in the kiln, usually the crown.

A number of different forms of recording instruments are in use giving single and multiple records. Multiple recorders are becoming most common, and by the installation of suitable switch arrangements a number of pyrometer records can be taken on the one recording instrument. A further convenience consists of an automatic recorder in which the temperature is permanently registered on paper in the form of a curve and made immediately available for comparison with other records.

The main advantage in using electrical pyrometers is the fact that the record is continuous and shows rising or falling temperatures immediately as they take place.

Cones show rising temperatures only and lag somewhat behind the actual temperature, thus making the control rather loose. A slight falling off in temperature at any stage means an added cost for fuel to make up the loss.

There are many dependable and highly practical forms of thermo-electric pyrometers on the market, and this aid to greater efficiency in kiln burning is well worthy of consideration by even the smallest plant.

The instruments require a fair amount of care and the thermo couples require to be standardized and renewed from time to time.

Methods of Overcoming Scumming and Drying Defects.

Scumming Defects.

Clays that contain soluble salts, particularly the sulphates of calcium and magnesium, which appear on the surface of the finished ware as a scum, require special treatment at the tempering stage. It has long been the practice to add some salt of barium, such as the chloride or carbonate, to the tempering clay to cure this defect. Recently barium fluoride has been added to the list.

Barium chloride is more readily soluble than barium carbonate. The chloride is, therefore, easier to mix with the clay in the tempering water, and the action is more rapid. This also applies to the fluorides. If too much chloride is added, however, the excess acts as a scum-forming salt, and so defeats its purpose. The carbonate does not do this, so that an excess is not dangerous. According to Staley,[1] the fluoride, when used in excess, gives a scum in drying, but this burns off in the fire.

The quantity of barium salt required to prevent scumming can be roughly determined by making up a number of batches of clay, with varying amounts of salt from 0 up to 2 per cent, each lot differing by a half per cent. After drying and burning the test pieces, choose the one lowest in the series showing no scum and use the amount of barium salt indicated.

A more refined method for plant control recommended by Emley and Young[2] requires a number of bottles. In each of these is placed 100 grams (2 oz.) of the clay and enough water to fill the bottles three quarters full. They are then set in a warm place for a short time and shaken thoroughly until the clay has become finely divided. A 1 per cent solution of the barium chloride or fluoride is then added to each bottle: 1 c.c. in the first bottle, 2 c.c. in the second, etc. Store in a warm place for twelve hours with occasional shaking. Add a pinch of lime to each bottle, and, after the clay has settled, draw off some of the clear liquid and add to it a few drops of sulphuric acid. If turbidity develops, the bottle contained an excess of barium salt. If, for example, the liquid from bottles 1 to 4 remains clear on the addition of sulphuric acid, while that from 5 to 10 shows turbidity, then the ratio of barium salt to clay in bottle 5 is the proper ratio to be used in working the clay.

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[1]Staley, Trans. Amer. Ceramic Soc., Vol. XVII, 1915, p. 201.
[2]Emley and Young, Trans. Am. Cer. Soc., Vol. XVII, 1915, p. 245.

Drying Defects.

Many of the Saskatchewan clays are defective in their drying qualities, and before they can be used for the manufacture of ware by the plastic process they require to be partially dried.

Clays that crack in drying are also, as a rule, very stiff and sticky in their working qualities. In eliminating the cracking defect some attention is necessary to overcome the stiff and sticky nature.

Several methods have been devised to overcome cracking in the drying and burning of clays. It has been found that sodium chloride (common salt) when added to the tempering water, in amounts of one half to one per cent of the clay used, decreases the rate of drying, and decreases or eliminates the cracking. It tends to cure this defect but it has no appreciable effect on the working qualities.

The salt causes a scum to appear on the air dried ware but this disappears in the burning, and, as pointed out by Staley[1], tends to produce clearer and brighter colours. The salt has further beneficial effects in reducing the vitrification temperature and increasing the vitrification range, the temperature of overfiring remaining the same as for the untreated clay.

The addition of a per cent or two of lime to defective clay at the tempering stage has been found to improve the working qualities and to materially reduce the tendency of the ware to crack in drying On the other hand it has the disadvantage of bleaching the colour of red-burning clays and making a scum appear on the surface of the ware. Hence, this cure cannot be used in cases where colour is important.

The third method consists of preheating the clay, in a suitable apparatus, to a temperature sufficient to destroy part of the excessive plasticity. The temperature required to accomplish this varies with each clay, but, in general, it is around 550°C (990°F.)

Keele[2] experimented with the red-burning clay used at Estevan for dry-press brick, and found that, when ground to pass a 16-mesh screen and subjecting it to a temperature of 550°C. for fifteen to thirty minutes, it could be made workable by the stiff-mud process.

In practice this clay is subjected to a slight preheating or drying treatment in a rotary kiln, but it is doubtful if the apparatus, as operated, would give a temperature treatment sufficiently high, and long enough, to render the clay workable by the plastic process.

Rotary kilns, for preheating clays of Tertiary age, similar to those of Saskatchewan, are in successful use in a number of brick plants in the north central United States.

In summary, then, preheating improves both the working and drying qualities but requires an additional equipment and fuel to operate. Lime

[1]Staley, Trans. Am. Ceramic Soc., Vol. XVII, 1915, p. 702.
[2]Keele, Memoir 25 G.S.C., p. 83.

treatment improves the working and drying properties but produces a scum. Salt treatment improves the drying but does not improve the working qualities to any extent.

The commercial possibility of using any of these methods depends largely on the relative cost of salt, lime, and fuel. The cost of lime puts it out of the question in southern Saskatchewan. For the Estevan district, the more efficient use of the lignites would give a very cheap gas fuel for preheating, and a combined mild preheating and salt treatment might be tried.

RECORDS OF TESTS.

The laboratory tests carried out on the samples collected in the field were designed to show the general working qualities of the materials, their moulding, drying and burning properties.

The samples were first allowed to reach the air dry condition, and were ground to pass a 16-mesh screen. A weighed quantity of clay was then mixed with water to develop maximum plasticity, and, after thorough kneading, made into small stiff-mud bricklets in a mould 4″ × 1½″ × 1″ in size.

Full sized wares were made from some of the clays by the stiff-mud process, using an experimental auger machine for moulding and a small wet pan for tempering. Hand made brick in imitation of the soft-mud process were made of those clays which checked in drying when made in the stiff-mud machine.

A large block, at least 3 inches square, was used for all drying tests. Small pieces of tender clays often dry without checking whereas large blocks approaching full sized brick may crack badly.

In most cases the drying and total shrinkages were measured on the small standard test piece.

Clays that were difficult to work by the stiff-mud process were tested for the dry-press method. For this purpose the material was reduced to pass a sixteen-mesh screen, moistened to the proper condition, and pressed in a small briquette machine into test pieces measuring 3¼″ × 2″ × 1″. When the size of the sample allowed of it this was supplemented by tests on full sized brick pressed in a commercial screw press.

Burning to the lower cones was carried on in the laboratory test kilns, while the tests requiring temperatures above cone 3 were burned in commercial kilns, in Kingston and Hamilton.

Fusion or deformation tests were made in laboratory gas kilns, and for the higher temperatures, in a Hoskins electric kiln.

The absorption was obtained in the usual way, by immersion in water, and the calculation made in terms of the dry weight.

CLAYS OF THE CYPRESS HILLS DISTRICT.

South of the Cypress hills, the Frenchman river has cut a deep trench in the Tertiary and Cretaceous formations and exposed the valuable refractory and semi-refractory clays which occur at the base of the Tertiary.

A typical section measured on the big butte at the junction of Concrete coulée with the main valley near Ravenscrag resulted as follows:—

Top—Yellow silts and sands, calcareous	40 feet
Hard yellow sandstone	1 "
Yellow clays and silts	20 "
Dark grey carbonaceous clay	6 "
Yellow sands and silts	15 "
Dark brown carbonaceous clay	11 "
Fine sands and thin lignite seams	12 "
Dark brown carbonaceous clay	1 "
Strong greenish-yellow clay	8 "
Dark grey clay	2 "
Yellow silty clay	5 "
Yellow sands partly indurated	7 "
Hard calcareous material	1 "
Yellowish silty clays and sand	10 "
Black carbonaceous clay	1 "
Light brown clay	6 "
Carbonaceous silty clay and thin lignite seams	4 "
Yellow silts and silty clays	18 "
Yellow sands	16 "
Brown carbonaceous shale	4 "
Lignite (poor quality)	4 "
Yellowish-brown sticky clays containing selenite crystals	27 "
Dark brown carbonaceous clay,	2 "
Brown clay showing iron oxide stains	5 "
Thin irregular bed of limonite	½ "
Fine grey clay weathering white	11 "
Dark brown carbonaceous clay	1 "
Light brown clay weathering white	5 "
White clay silt (mostly fine quartz)	6½ "
Lignite and carbonaceous material	1 "
Light grey clay	2 "
White to grey sands made up of angular quartz grains, clay matter, and minute limonite concretions	55 "
Coarse rusty sands and clays	125 "
Lead grey shales	50 "
Total	483 feet

Besides the clays of the Cretaceous and Tertiary mentioned above, the glacial or recent alluvial clays of the valley bottom are of some importance.

The section in the valley side can be divided into five distinct colour horizons; (1) the dark slate coloured Pierre shale at the bottom is followed by (2) rusty sands and clays, (3) a light grey band consisting of grey sand at the base passing into light grey or white clays and sands towards the top, (4) dark grey clays and silts and thin lignite seams, (5) and yellow clay silts and sands to the top. In all, there is a total thickness of 480+ feet exposed. (See Frontispiece).

Above the Pierre shale the individual beds are very irregular and lens like in character, seldom being continuous for any distance.

The most striking feature of the exposures along the valley from Palisade to Eastend is the white band at the base of Fort Union. This band though only 20 to 50 feet in thickness forms a very conspicuous feature of the section. Exposures of it in the distance look like great snow banks. The clays and sands in it, like those above, graduate almost imperceptibly one into the other and seldom remain pure for any distance. They are usually associated with thin beds of lignite and carbonaceous shale; a relation which persists wherever the white band has been found in the Province.

From South Fork to Palisade the Canadian Pacific railway follows the deep valley of the Frenchman river, and for most of this distance, some fifteen miles, the white band clays can be seen outcropping in the valley sides within a mile or so north and south of the railway.

In the vicinity of the town of Eastend the best workable outcrops are to be found. To the north and south of the town, erosion has bared considerable quantities of the valuable white clays.

West of Eastend there are numerous outcrops of the white clays, but towards Ravenscrag the overburden thickens and erosion has not been so extensive. West of Ravenscrag the white band thins to 20 feet near Palisade and then disappears under a covering of glacial drift. A small outcrop occurs well up the hills to the northwest near Belanger post office, but nothing more is seen of it until the deep valley of 4 Mile coulée is reached. Here it is found near the base of the section, as a very thin and rather sandy bed.

The deep cut of Battle Creek valley contains further exposures but the quantity of material available and the location make the occurrence of little economic value.

The clays above the white band are not well exposed near Eastend but appear in greatest thickness near Ravenscrag. Many of these clays are defective in their drying qualities, and others, particularly the yellow calcareous clay silts of the upper part of the section, scum badly.

The white beds dip some 9 feet to the mile in an easterly direction, and, from the top of the valley sides near Palisade, decline to the bottom of the valley some 12 miles southeast of Eastend.

The white clays are also found in the west facing escarpment of Boundary plateau.

The white clays of this section of the Province are not as refractory as those farther east and are best suited for making stoneware pottery and sewerpipe, or clay products that are burned to vitrified bodies in a range from cone 5 to 9.

The clays vary from place to place in their working qualities, sometimes being silty, and again very fine and plastic. Selenite is present in most of the beds and soluble salts are to be contended with in the more plastic ones.

Some of the clays contain small concretions of iron oxide, usually developed around grains of sand, but these can be removed by washing. Occasionally masses of concretionary iron oxide (clay ironstone) occur at the top of the section of white clays and stringers of it have penetrated vertical joint planes in the clay. In this connexion it is important that plenty of good clean water is to be had from the Frenchman river for washing the clays.

Old Fort Walsh.

In the valley of Battle creek near the old Mounted Police station, known as Fort Walsh, there are numerous outcrops of the white clays.

401. On the S.E. ¼ sec. 15, tp. 7, range 29, west of the 3rd mer., the quartzite gravel at the top of the valley side is underlain by a thick bed of sandy white clay. A sample of this clay required only 18% of water to develop maximum plasticity. It dries without defect to a shrinkage of 2·3%. At cone 06 it has a total shrinkage of 2·6% and an absorption of 10·5%. At cone 7 the total shrinkage is 6·3% and the absorption 4·6%. Vitrification is complete at cone 9 and deformation follows with cone 15.

This material could be used for brick or mixed with other clays of the vicinity for hollow ware.

402. On the N.W. ¼ sec. 8, tp. 7, range 28, west of the 3rd. mer., a cut bank in a coulée shows a section of sands, clays, and thin lignite seams. About half way up there is a five-foot bed of yellowish coloured clay under a thin lignite seam. This clay is defective in its drying properties, when wet moulded, but works well when moulded dry-press. At cone 06 the shrinkage is 5·0% and the absorption 19·0%. The burnt colour is a pleasing pink with a speckled effect.

On sec. 27, tp. 7, range 29, west of 3rd. mer., the following section was observed in the west side of Battle Creek valley:—

Top—Oligocene gravel	5 feet +		
Dark brown clay	2 „	0 inch	
Thin lignite seam	0 „	1 „	
Cream coloured clay	4 „	0 „	No. 404.
Yellow silt	1 „	0 „	
White clayey sand	4 „	0 „	
White clay	2 „	6 „	No. 405.
Black carbonaceous clay	4 „	0 „	

404. This is a fine plastic clay of stoneware grade. It requires 29 per cent of water to mould it in the stiff-mud condition and it dries without defect to a shrinkage of 7·3 per cent. Burned to cone 03 the total shrinkage is 10·0%, the colour is buff and the body steel hard, with an absorption of 10·8%. At cone 5 the body is vitrified with a total shrinkage of 15·0%. Deformation takes place with cone 13.

This clay is well adapted to the making of stoneware pottery.

405. The sample collected from the bed indicated as 405 was largely lost in transit to the laboratory and no burning tests were made of it. It is a good stoneware clay, however, and like No. 404 deforms with cone 13.

Similar clays to Nos. 404 and 405 were noted in an excavation a short distance west of Coulée post office. It is dug by the people of the neighbourhood and used for mud plastering houses and barns.

Belanger.

416. North of Belanger post office and sec. 32, tp. 7, range 25, w. of 3rd. mer., there is a small outcrop of white sandy fireclay, dug locally for mud plaster. It contains a considerable proportion of clay which makes a good bond and the sandy nature of the material gives it a low air shrinkage (4·0%).

Burned at the temperature of cone 9 the total shrinkage is 8·0% and absorption 4%. Deformation takes place at cone 27.

The location of this material gives it very little outside economic importance. The settlers of the vicinity will find it of value for making their own stove linings as well as plastering the rough type of buildings in use at present.

Palisade.

In the Frenchman River valley the white band was not found west of the confluence of Fairwell creek. It is very thin and outcrops near the top of the butte on sec. 10, tp. 6, range 24, w. of 3rd. mer. It consists almost wholly of greyish-white silt and sand for 40 feet with a two-foot bed of cream coloured clay on top. The younger Oligocene gravels and sands are here in contact with the white band.

544. On the north side of the valley, on sec. 22, tp. 6, range 24, w. of 3rd. mer., another exposure was found in which the white clay makes up 20 feet of a fifty-foot section.

The clay is separated from the white sands below by 3 feet of lignite of poor quality.

Tests on the clay (No. 544) show fairly good working and drying qualities. The air shrinkage of 8·3% is within working limits for stoneware, but grog would be necessary for rougher goods such as sewerpipe.

The body is steel hard at cone 07 with an absorption of 8·2%. Vitrification is complete at cone 7 with a total shrinkage of 16·5%. Complete deformation occurs about the temperature of cone 15.

This material is 2 miles from the railway on the opposite side of the river, and hence not so easy of access as outcrops to the east.

Ravenscrag.

417. Near the village of Ravenscrag there are numerous outcrops of the white band clays. They can be seen along the valley to the east and west as a white line half way up the slopes and in masses included in slip blocks in the valley bottom.

Sample 417 was collected from a point on the north side of the valley on sec. 30, tp. 6, range 23, w. of 3rd. mer. It is a sandy clay with fair plasticity, requiring but 23% of water to mould in the stiff-mud condition. The drying properties are good and the air shrinkage is 5%.

Burned to cone 03 the test pieces show swelling characteristic of siliceous clay; the total shrinkage being 4·4%. At this cone the colour is a dirty cream, and the body is fairly dense, giving an absorption of 13·3%. Vitrification is not quite complete at cone 9. Deformation takes place at cone 20.

The raw material contains minute iron oxide concretions and these appear in the bricklets burned above cone 1 as black specks. They are particularly prominent when burned under reducing conditions

418 to 423. The most important beds exposed in Eagle butte, at the junction of Concrete coulée and the Frenchman River valley, were sampled and tested as follows. (See page 27 for measured section.)

No. 418A is a six-foot bed of clay near the top of the section. It is slightly calcareous and contains lignitic matter and numerous leaf impressions

It works up to a rather stiff mass with 27% of water and dries safely without checking. However, a white scum is very prominent and in the burned pieces it completely covers the red colour of the body. The air shrinkage of 7·6% is not excessive.

Burned to cone 06 the total shrinkage is 8·6% and the absorption 20·4%.

When mixed with 25% or even 50% of the yellow calcareous silts overlying it, this clay would make good common brick and hollow ware by the stiff-mud process.

The heavy scum developed on the brick would make them of no value for facing purposes.

No. 418 is a thick bed of dark brown carbonaceous clay. The large amount of finely divided carbonaceous matter present makes this clay of little value to the clayworker.

No. 419 is an 8-foot bed of greenish-yellow clay about 66 feet below the hard sandstone horizon of the top part of the section. It works up to a stiff, but not sticky plasticity with 25% of water. Slow drying can be accomplished without cracking but the shrinkage of 9% is excessive. Mixed with some of the sand, found a few feet below it, the drying and burning shrinkages could be reduced and the material made workable.

Burned to the temperature of cone 06 the body is steel hard and the colour a fair red. A small amount of scum is present, but the addition of a very small percentage of barium salt cures it.

Mixed with 30% sand the drying properties would be improved and the shrinkage reduced to within practical limits for making soft-mud brick.

This clay could also be used for red face brick, moulded by the dry-press process.

420. About half way up the section there is a hard band of non-plastic clay, which appeared much like flint clay. On testing a sample in the laboratory it was found to be a hardened calcareous clay of little value.

421. About eleven feet above the level of sample 420 there is a 6-foot bed of a light brown or yellowish clay. It is in a part of the section that consists largely of yellow silts, and differential erosion causes the clay to project beyond the general line of the section as a ledge.

A sample of this bed shows it to be a very stiff plastic clay, requiring 27% of water to obtain the best working consistency. It dries very slowly and will not stand fast drying. The air shrinkage of 7·0% is within practical limits and may be considered low in view of its stiff plasticity.

At cone 06 the body is hard and promising as a common stiff-mud brick material. The colour of the body is salmon bnt is obscured by a heavy white scum. Deformation takes place about cone 2.

This clay, like many other red-burning calcareous clays of the district, develops so much scum in burning that it must be considered doubtful as a face brick material. Its stiff nature when wet would make it hard to break down with ordinary crushers and rolls so as to mix in sand or other non-plastic material. If this could be done it could be used for making common stiff-mud brick, and perhaps hollow block.

422. The thickest bed in the white band of this localtiy is a greyish-white clay of the stoneware type. A thin layer of limonitic sand overlies the white clay but does not extend its effects into the clay except along a few vertical joint planes. The clay has excellent plasticity when wetted with 24% of water and dries to a good strong body, without cracking, with a shrinkage of 7·6%.

Burned to cone 06 the colour is cream-white, the body dense and steel hard, the total shrinkage 9%, and the absorption 12·3%. Vitrification takes place between cones 5 and 7, and bloating starts at cone 9. Deformation is complete at cone 18.

The burning properties of this material suggest its use as a stoneware or sewerpipe clay.

422A. A mixture of equal parts of 421 and 422 made a very stiff body with [illegible] excessive shrinkage; 30–40% of burnt clay grog would be nece[illegible]e it workable.

Sewerpipe tests burned in a commercial kiln to cone 01 came out a yellowish-green colour without the least sign of salt glaze. The material of 421 is too calcareous for this purpose, but makes a good bond clay with grog for manufacturing hollow block or tile.

423. A bed of some 6½ feet of white silt is the most prominent material between the white clay and the thick sands at the base of the section. Under the microscope it is seen to consist largely of fine angular grains of quartz coated by white clay. Muscovite mica and black particles of hornblende are present in minor amounts.

This material has very little plasticity or binding power and hence would be of no value used alone, but mixed with the 17 feet of clay overlying it, the whole would make a good basis for a sewerpipe mixture.

On sec. 20, tp. 6, range 23, w. of 3rd. mer., to the south of the railway, some stripping has been done on a 4-foot coal seam occurring at the level of the white band. The coal is overlain by some 10 feet of plastic clays, four distinct beds in all separated by thin lignite seams. These light coloured clays are followed by yellow calcareous silts and grey plastic clays similar to those described as occurring at Eagle butte.

424. Number 424 is a light grey clay immediately overlying the 4-foot bed of lignite. It requires the large amount of 30% of water to develop maximum plasticity, and at its best this is excessive or sticky. Slow drying can be accomplished, but, without grog, it would not stand fast drying. The air shrinkage of 10% is excessive.

Burned to cone 06 the colour is a light pink shade, the body is steel hard, the total shrinkage is 12·0% and the absorption 12·0%. Vitrification takes place at about cone 4 and bloating of the body starts at cone 7. Deformation is complete at cone 11.

425. Number 425 is the thickest bed in the section. It consists of 4 feet of greyish-white clay, which worked up into a mass of sticky plasticity with 28% of water. The air shrinkage of 8·5% is on the verge of being excessive. Slow drying can be accomplished, but for fast drying considerable grog would be necessary to open up the body.

Burned to cone 06 the total shrinkage is 9·6% and the absorption 12·3%. At this temperature the body is steel hard and pink in colour. Vitrification takes place at cone 5 with a total shrinkage of 14·6%. Bloating of the body starts at cone 6 and deformation follows at cone 9.

426. Number 426 is a 2-foot bed of greyish-brown clay next in order above 425. It requires 31% of water to make it workable and at that it is very sticky. The air shrinkage of 13·0% is excessive and full sized brick could not be dried safely.

Burned to cone 06 the colour is dark cream. At this temperature the body is steel hard with a total shrinkage of 13·0% and an absorption of 11·0%. Vitrification is complete at cone 1, and deformation occurs at cone 7.

Number 427 is a light yellow or cream coloured clay, requiring 32% of water to develop the maximum plasticity. The working qualities are not good, the mass being stiff and sticky. Large pieces could be dried with difficulty, the air shrinkage of 10·0% being excessive.

Burned to cone 03 the body is steel hard and of a light salmon colour. At this temperature the total shrinkage is 14·0% and the absorption 9·0%. Vitrification takes place at about cone 4 and bloating starts with cone 7. At cone 10 the body is completely deformed.

These clays (424–427) are characterized by an excessive or sticky plasticity. They take up large percentages of water, and, with the drying out of this water, the shrinkage is correspondingly high.

A mixture of the clays, in the proportion shown in the bank, showed no improvement in working qualities over the individual clays. The addition of 33⅓% of grog (through 12 mesh) improved the drying and burning qualities. Better results would be obtained by mixing in about 25% of a clay found on the north side of the valley. Unless used in connexion with other clays of the district these beds have no value in themselves for plastic ware because of the defects in drying and burning. They can, however, be used for making dry-pressed face brick.

On the north side of the Frenchman River valley in sec. 23, tp. 6, range 23, w. of 3rd. mer., the following measurements were taken on the outcrop of the white band from bottom to top.

Carbonaceous sand	1 +	foot	
Lignite	2	"	
Carbonaceous silt	$\frac{1}{3}$	"	
Lignite	1	"	
Fine white sand	$\frac{2}{3}$	"	
Grey clay with rusty spots	2	"	
Dark brown clay	$\frac{1}{2}$	"	
Greyish-white clay	2	"	No. 429.
Grey clay containing rusty spots	1	"	
Fine white silt	$2\frac{1}{2}$	"	No. 428.
Greyish-white clay	$1\frac{1}{2}$	"	
Greyish-white sand containing numerous iron oxide concretions	6	"	
Grey clay containing much selenite	$5\frac{1}{2}$	"	
	26	feet	

At this point the white band does not contain as much clay as in exposures farther east near Eastend. Two of the cleanest beds were sampled and the tests resulted as follows:—

No. 429 is a fine [illegible] clay, greyish-white in colour. Mixed with 25% of water, the mass has excellent plasticity and dries safely, both slow and fast, with a shrinkage of 7%. Soluble salts are present and appear at the edges and corners of the drying ware, as feather crystals.

Burned to the temperature of cone 06 the body is hard and cream coloured. The total shrinkage is 8·0% and the absorption 15·0%. Vitrification is complete at cone 5 with a total shrinkage of 14·5%. Bloating of the body starts at cone 7. The vitrified body is a dark stoneware grey. Deformation takes place at cone 13.

Number 428 is a clay silt in which the silt particles are mostly of angular quartz. It has very low plasticity and required only 20% of water to mould in the soft-mud way. The silty nature of the material makes drying of the test pieces proceed very fast. The drying shrinkage amounts to 5%.

Burned up to cone 5 the body shows swelling, but beyond that cone shrinkage proceeds to 8·3% at cone 9. At the latter cone the body is white and steel hard with an absorption of 5·8%. The body is deformed completely at cone 22.

The highest bed in this section is the thickest, but it is badly contaminated by selenite and iron oxide nodules. It would have to be washed to be of use for stoneware or sewerpipe. The whole section would make a good face brick mixture worked either by the stiff-mud or dry-press process. Because of the presence of considerable concretionary iron oxide material it would not be a good section to work for sewerpipe clay.

Eastend.

On secs. 7 and 8, tp. 7, range 21, W. of 3rd. mer., there are excellent exposures of the white clays at an elevation of about 150 feet above the railway in the valley to the east. The amount of overburden is not great and the amount of good clay shown is exceptional. An opening has been made in the side hill and the following beds exposed:—

Glacial drift	1–10 feet	
Grey plastic clay	8 „	No. 430.
Yellowish clayey sand	2 „	
White plastic clay	5 „	No. 431.
Purplish-grey plastic clay	2 „	No. 432.
White plastic clay	6 „	No. 433.
	23 „ below glacial drift.	

The beds in this particular outcrop are good sewerpipe clays but for making stoneware they must be selected. The presence of appreciable amounts of soluble salts requires an extra amount of water in the washing of this material, otherwise trouble is caused by the clogging of the pores of plaster moulds by crystallization of the salts.

430. This is a dull grey-coloured clay, very stiff and sticky in its working qualities, requiring 27 per cent of water to develop maximum plasticity. It contains very fine grained concretionary iron particles, and gypsum lumps up to ½ inch in diameter. Soluble salts are also present making washing necessary for use in making stoneware pottery. The drying qualities are good and shrinkage of 7 per cent not excessive. It burns to a cream-coloured body at all temperatures up to cone 5, but the unwashed material is speckled with fused iron spots at cone 7 and more so at cone 9.

The total shrinkage at cone 9 is 14·3 per cent and the absorption 6·8 per cent.

Complete vitrification does not take place until cone 11 is reached and the body deforms at the temperature of cone 23. The same bed sampled one mile east on sec. 36, 6, 22, w. of 3rd. is slightly more refractory, not vitrifying until burned to cone 11 and requiring the temperature of cone 26 to cause deformation.

431. This is a very plastic greyish-white clay which works up to maximum plasticity with 26% of water. It dries well in large pieces with a shrinkage of 6%. It is fairly free of concretionary iron grains and gypsum, and soluble salts are not as prominent as in the overlying clay (430). The burnt colour is white to cream up to cone 5, beyond which it assumes the typical stoneware grey. Vitrification takes place at cone 7 and the body begins to bloat at cone 9.

PLATE V

An outcrop of the Whitemud stoneware clays in the Frenchman River valley, west of Eastend, Sask.

PLATE VI

Whitemud stoneware clays, being worked on sec. 36, tp. 6, range 22, w. of 3rd. mer , near Eastend, Sask.

The total shrinkage at cone 7 is 15 per cent.

432. Particular attention must be paid to this bed by those using these clays for stoneware because of the rather high content of soluble salts. In casting or pressing pieces from this clay the pores of the plaster of paris mould soon get clogged by the salts crystallizing in them, after the mould has been used several times, thus causing the ware to stick to the mould. It also contains fine-grained iron oxide concretions.

This clay has excellent plasticity, requiring but 23% water to mould stiff-mud. It dries well with an air shrinkage of 8·3%. The small amount of water required to attain maximum plasticity in this clay does not appear to accompany a low air shrinkage.

The burnt colour is a dirty cream up to cone 5 where it assumes a grey tint, characteristic of the vitrification range. Vitrification is complete at cone 7 and bloating begins at cone 9. The total shrinkage at vitrification is 15 per cent.

433. The lowest workable bed is the thickest and best white clay of the section. It has excellent working qualities, requiring 24% of water to develop the best plasticity, and drying to a good strong body with an air shrinkage of but 5 %. It is free of concretionary iron oxide lumps but there is a small amount of crystalline gypsum present, making washing necessary for pottery.

The burnt colour is cream up to about cone 5, where the tone becomes grey. Bloating does not become serious until cone 10, giving a wider range for burning than the two overlying beds.

This bed is the best stoneware clay of the district and can be recognized in other outcrops within a couple of miles southwest.

433A. A mixture consisting of the three lower beds 431, 432, 433, in the proportions represented in the bank: 35% 431, 20% 432, 45% 433.

Twenty-five per cent of water was required to develop maximum plasticity. The working and drying qualities were good, showing an air shrinkage of 6%.

The burnt colour is cream up to cone 5, beyond which it is grey. Vitrification takes place at cone 7 with a total shrinkage of 15%.

It takes a good salt glaze in a range from cone 1 to cone 7.

On sec. 36, 6, 22, 3rd. there are several good exposures of the white band, particularly on a long pointed erosion form (see Plate VI) north of Wm. Days house. The beds resemble those of the previously described section except in the absence of a bed corresponding to 432.

A considerable quantity of clay from this section was shipped to Medicine Hat during the latter part of 1916 for the manufacture of stoneware goods.

434. The lowest clay bed of the section is a light grey, almost white plastic clay requiring 25% water to mould in the stiff-mud condition. It dries safely with a shrinkage of 6% to a body of good strength. Burned in a range from 06 to 9 the colour changes from a creamy-white to stoneware grey. The total shrinkage at cone 5 is 12% and the absorption 5·4%. The body is completely vitrified at cone 7 and continues good to cone 9, with a total shrinkage of 15%. Deformation takes place at the temperature of cone 16.

435. This is a rather silty white clay, requiring only 23% water to mould. It dries safely with a low shrinkage of 4·5%. The colour is cream in a range from cone 010 to 7, beyond which it turns grey. The body is nearly vitrified at cone 9, having only 2% absorption and total shrinkage of 11%. Deformation takes place about cone 19.

435A. A mixture of half and half 434 and 435 has fair plasticity and dries well. It acts much like 434 in the fire, giving a vitrified body at cone 7, with a total shrinkage of 13·3%. Deformation takes place at cone 20, indicating an increase in refractoriness.

436. The topmost bed of the white band is similar in colour and refractoriness to the corresponding bed on secs. 5 and 6, tp. 7, range 21, and represented by No. 430. It is a dark grey clay largely coloured by organic matter. The plasticity with 25% water is excellent and moulded pieces dry safely with a shrinkage of 7%. The burnt colour is cream-white up to cone 9 at which temperature the total shrinkage is 9·6% and absorption 9·3%. Complete vitrification takes place at cone 12 and deformation starts at cone 26. This is a No. 3 fireclay and the most refractory clay in the district.

The three clays described above make a good sewerpipe mixture but only the lower two beds should be used in a mixture for vitrified stoneware. The top clay is a good refractory material.

South of Eastend near the top of the valley side on sec. 25, tp. 6, range 22, 3rd. mer., there are several buttes showing the white clays. One of the largest sections of the white band in the district was found on one of these buttes. Six individual beds were sampled

Glacial drift	very thin.	
White clay, becoming sandy towards top, selenite and iron concretions present	8 feet	No. 437.
Greyish-white clay	5 "	No. 438.
White plastic clay containing iron concretions	4 "	No. 439.
White clayey sand	1 "	No. 439.
Dark grey clay	1 "	
White clay with thin sandy bands	4 "	No. 440.
White clayey sand	2 "	No. 441.
Light grey clay with thin sandy bands	3 "	No. 442.
Brown sand, lignite and clay	1½ "	
Brown sand	4 "	
Yellow and grey coarse sands	25 "	

The upper part of the section consists wholly of clay but towards the base it becomes more sandy and concretionary, iron oxide lumps are prominent.

Beds 438 and 437 are clays of excellent working qualities but 439 is inclined to be sticky and contains small granular iron oxide concretions.

437. Light grey, almost white stoneware clay which requires 24% water to develop maximum plasticity. It contains gritty material and would require to be washed for pottery. It dries well with a shrinkage of 6%. A minor amount of soluble salt is apparent at the corners and edges of the dried test pieces where evaporation is most intense.

Burned to cone 1 the colour is cream-white, the body having a total shrinkage of 7·6% and an absorption of 21·7%. Vitrification takes place with cone 7 at which temperature the colour is a light grey and the total shrinkage 12·0%. Deformation takes place with cone 16.

This is a good stoneware or sewerpipe clay and could also be used for making brick or structural hollow-ware if mixed with the other beds of the section.

438. This is a fine white or light grey clay that darkens on the surface in weathering. It is one of the best working clays of the district. Soluble salts are present in small amount and appear at the corners and edges of moulded pieces when air drying. However, there was no trouble experienced with the washed clay when cast or pressed in moulds.

The plasticity is excellent and the maximum develops with about 25% of water.

The drying qualities are good and the air shrinkage of 7% is within practical limits.

The burnt colour is cream at temperatures up to cone 3. Beyond this the colour changes to stoneware grey and vitrification is complete at cone 7. Bloating of the body starts at cone 9 and complete deformation takes place about cone 20.

The total shrinkage is 7% at cone 03 and the absorption 14·6%. At vitrification the total shrinkage is 14·0%.

438W. Washing this clay reduces the vitrification temperature to cone 5 and the shrinkage to 12·3%.

This clay is an excellent stoneware or modelling clay and should be saved for this purpose and used in the manual arts departments of the schools of the Province or in small potteries.

Analyses of Clays from Eastend, Sask.

	434.	435.	436	438 W.
SiO_2	69·04	68·24	68·30	66·94
Al_2O_3	21·45	22·33	21·89	24·09
Fe_2O_3	1·84	1·61	2·10	1·40
FeO	·35	·30	·24	·37
CaO	·46	·46	·48	·30
MgO	·68	·48	·31	·28
K_2O	2·72	2·77	·81	2·58
Na_2O	·43	·98	·80	·94
CO_2	·07	·07	·10	·10
H_2O	3·56	3·25	5·50	3·56
	100·60	100·49	100·43	100·56

439. The clay of this bed is much like No. 438 in appearance, but when wetted to its maximum plasticity it is inclined to be sticky. It is also contaminated by numerous minute concretionary iron oxide particles. These can be easily washed out but the sticky nature of the plasticity remains.

The drying qualities are good but the air shrinkage of 8·5% is on the verge of being excessive. The sticky qualities of this clay cause it to dry slowly, and when pressed in plaster moulds it has a tendency to stick to the plaster in spots, and strains so induced cause cracking. The sand-like iron oxide concretions have to be washed out to use it on the potters wheel.

In burning, the colour is cream-white at the lower temperatures, but changes to grey approaching the vitrification point. At cone 03 the total shrinkage is 10·0% and the absorption 12·4%. Vitrification takes place at cone 7. At this temperature the fine iron oxide concretions are evident as black fused spots, but this is not so apparent as in No. 440. Deformation takes place at cone 20.

This clay when washed and mixed with one of the more silty clays makes a good stoneware body.

440. The lower three beds of this section are not as thick as the upper ones and except for No. 440 they are more sandy.

Bed No. 440 consists of white or light grey clay bands with thin sandy partings. It works up to a body of excellent plasticity with 26% water and dries safely with a shrinkage of 8·6%. Soluble salts are quite evident as scum.

The colour of the burnt body is a dirty cream up to cone 3 beyond which it turns dark grey. The total shrinkage at cone 03 is 12%, and vitrification is about complete at cone 5, the total shrinkage at this temperature being 13%. Bloating of the body occurs at cone 7 and is very bad at cone 9. Complete deformation takes place approaching cone 14.

Near the vitrifying point the body is finely speckled by fused iron oxide spots. It would be necessary to wash this material for pottery

PLATE VII

Stoneware pottery and sewerpipe, made from Eastend clays illustrated on Plate VI.

work. In doing so the vitrifying temperature is reduced to cone 3, but the total shrinkage of 15% shows an increase.

For stoneware pottery work this bed should be avoided as long as possible in favour of other clays containing less amounts of soluble salts.

441. This is a fine white silt consisting largely of minute angular quartz fragments coated with clay. Alone it is too silty to be of use but when mixed with the whole section would help make a good sewerpipe body. It is quite refractory, standing up to the temperature of cone 25 without deformation.

442. The lowest bed in the section consists of a light grey clay with thin sandy lenses and partings. It is discoloured here and there by streaks of iron oxide concretions. Selenite lumps are also present as an impurity.

The plasticity of this material is fair, inclining to be short. The drying properties are good and the shrinkage of 7·0% not excessive.

Burned up to cone 06 the total shrinkage is 7·3% and the absorption 14·0%. At this temperature the colour is a light pink.

Vitrification is about complete at cone 5 and deformation takes place at cone 12.

This bed is too thin (3 feet) to be of value alone but would work into a sewerpipe body with the rest of the section.

442A. Near the above described section and on the same lot there is a 3 to 4-foot bed of lignite. It occurs at an elevation higher than that of the white band.

Overlying the coal there is a four-foot bed of red-burning clay, which, in turn, is covered by 8 feet or more of sand.

The clay is defective in having a very high shrinkage and soluble salts that cause a scum to appear on the burned brick. The position the clay occupies between the sand and lignite would not allow it to be mined with the lignite. It would be required as a roof to hold the sand.

444. On or about sec. 27, tp. 7, range 21, w. 3rd. mer., there is a high bluff containing one of the most complete sections of Fort Union and Oligocene beds known in the district.

The white band is represented by only 25 feet of grey clays, very stiff and sticky in their working qualities. The white or light grey sands, found below the white clays, in the exposures to the southwest, are not present here.

Near the top of the bluff there is a thick bed of a green and red mottled clay similar to the clays at the top of the section exposed in the escarpment south of Elkwater lake, Alberta.

This red and green clay is calcareous but it cracks badly in air-drying. Bricklets moulded dry-press burned weak and porous at 06 and firechecked badly at higher temperatures.

Mixing with grog does not help the working qualities because the clay shrinks so much in drying and burning that the brick becomes weak and porous.

445. North of Eastend in a small coulée on sec. 29, tp. 7, range 21, w. of 3rd. mer. the settlers of the vicinity are mining lignite from a 4½-foot bed. Another lignite seam only a few inches in thickness occurs above the main seam and is separated from it by 4½ feet of grey carbonaceous clay.

This clay works up into a stiff mass with 32% water. The air shrinkage is 9·0% and large pieces, dried slowly, do not crack; but it would be too tender a clay to use in the stiff-mud process.

In burning, the total shrinkage, at cone 03, of 10·6% is excessive and the red colour is obscured by a heavy scum. This material is of little value to the clayworker.

446. About half way up the bluff on sec. 29, tp. 7, range 21, w. of 3rd., there is a hardened band of clay which resembles a flint clay. Tests on it in the laboratory show it to be a hardened calcareous clay or impure limestone.

In glacial and early post-glacial time the Frenchman River valley was occupied by a much larger stream than at present. This river was over a mile wide in the vicinity of the present town of Eastend, where Eastend coulée joins the main valley. The character of the sediments, mostly clays and clay silt, indicates a wide sluggish river.

With the complete retreat of the continental ice the climatic conditions changed from moist to semi-arid and the river was reduced to a small stream some 30 feet across. It is now entrenching itself in the former flood plain and has reached a depth of about fifteen feet.

Near the town of Eastend a number of excellent cutbanks are to be seen along the river, and sample No. 500 was collected from a 10-foot section on the north bank of the river, about a quarter of a mile west of Strong's ranch house.

500. This is a clay silt of good plasticity requiring 25% of water to mould in the stiff-mud condition. It can be dried slowly with care, but would need 25% to 35% of sand to reduce the shrinkage (8·6%), and overcome checking in drying. Sand is available in the river bottom near at hand, but better results would be obtained with the red-burning Oligocene sand found to the northwest of Ravenscrag, some 4 miles distant.

Burned in a range from 08 to 03 the colour of the body is a fine red, darker at the higher cones and best at 06. At the latter temperature the total shrinkage is 8·6% and absorption 16·2%. Deformation takes place about cone 2.

This material treated with sand or burnt clay grog is valuable for making red common brick and drain tile. It can be worked either soft-mud or stiff-mud.

Southwest from Eastend along the Frenchman River valley, the white band outcrops near or at the top of the valley sides as far south as Watsons ranch. Southward from this locality the band dips beneath the valley and its place is taken by thick beds of grey and brown gumbo clays, of no value to the ceramic industry. These clays take up large quantities of water and in wet weather become very sticky. Large exposures are to be seen in the deep valley of Mule creek in tp. 5, range 17, w. of 3rd. mer.

On sec. 33, tp. 5, range 20, w. of 3rd. mer. along the east side of the valley, very prominent exposures of the white band are to be seen. The lower exposed part consists of 50 feet of coarse grey sand, somewhat clayey in places and discoloured here and there by iron oxide from the weathering of concretions.

The sands pass into fine white silty clay and this again is covered by white or light grey plastic clays. The silty clay bed is some 30 feet thick and the plastic clays total but half that amount.

The silty clay is represented by sample number 448 and the plastic clays by number 447.

On sec. 20, tp. 6, range 20, w. of 3rd. mer., extensive outcrops are to be seen in a coulée tributary to the main valley. Here the material is largely white silty clay similar to sample No. 448.

The overburden is very light, consisting of a couple of feet of boulder clay.

447. The mixture of clays in this sample works up into a mass of excellent plasticity with 26% of water. Drying may be carried on fast without danger of cracking, the air shrinkage being but 6%. Soluble salts are present and appear as a white scum or encrustation at the corners and edges of the dried pieces.

Burned to the temperature of cone 06 the body is cream-white in colour and of fair hardness. The absorption at this temperature is 13·8%.

At higher temperatures the colour changes to stoneware grey and vitrification is complete at cone 6 with a total shrinkage of 12·0%. Bloating of the body starts slightly above core 7 and is very bad at cone 9. Complete deformation takes place at cone 14.

448. Although this material has been described as a silt it contains a fair percentage of clay. Made up into stiff-mud with 24% of water the mass is short but can be worked. Drying is quite safe with an air shrinkage of 5·0%.

When burned to the temperature of cone 06 the body is fairly hard, the total shrinkage 5%, and the absorption 15·0%.

Vitrification is complete at cone 7 with a total shrinkage of 12·3%. Deformation takes place at cone 15.

The silt contains minute iron oxide concretions and when burned under reducing conditions above cone 1 these appear as fine black specks on the faces of the test pieces.

A mixture of 447 and 448 in the proportions found in the bank would make excellent sewerpipe material. The good working qualities, low shrinkage, and low vitrification temperature are all points in its favour.

From the foregoing descriptions it is apparent that the Eastend district is well supplied with good clays suitable for making sewerpipe, stoneware, and structural clay products. The presence of these clays along the railway and along a clear fresh water stream is particularly fortunate, and should a cheap fuel supply, such as gas, be struck within a commercial radius of the district, the town of Eastend should develop as a clayworking centre for the middle west.

CLAYS OF THE SWIFT CURRENT DISTRICT.

Swift Current.

The town of Swift Current is a railway centre for the Canadian Pacific railway and an important distributing point. An examination of the vicinity failed to discover any good clays. The valley silt of Swift Current creek looks promising, but it presents the usual drying and scumming difficulties.

The Pierre shale outcrops in the terraces along the west bank of the creek just north of the town, beginning near the hospital. It is dark grey to brown in colour and contains a considerable quantity of flakes and rosettes of gypsum. This shale is defective in so many qualities that it is useless for the manufacture of burned clay products.

538. On the outskirts of the town southeast of the bridge over Swift Current creek two terrace levels show stratified clay and silt to a depth of 30 feet. A sample of the upper 20 feet works up to a mass of fair plasticity with 28% of water. The air shrinkage amounts to only 5% but nevertheless the brick crack in the drying process.

Burned to cone 05 the total shrinkage is 4·3%, the colour a dirty salmon due to scum.

It would be possible to make a soft-mud brick from this material by adding about 25% of sand and 0·1% of salt. The product would be a low grade common brick suitable for backing purposes only.

539. A second sample collected near the Canadian Pacific railway siding east of the bridge acted similar to 538.

Beverley.

South of Beverley on sec. 33, tp. 14, range 15, w. of 3rd. mer., the upper part of the Pierre shale outcrops in a coulée tributary to the valley traversed by the Canadian Pacific railway. The Pierre is here quite light-coloured, and sandy, with thin bands of dark clay shale. Gypsum is present in noticeable amounts. Samples of both the sandy and fat clayey beds were collected (540 and 541) and tested. Both materials show excessive shrinkage, cracking badly in air-drying, and, although the colour of 540 when burned is a good red, the effect is spoiled by white lumps of gypsum.

The Pierre shale of this vicinity is to be avoided as a raw material for manufacturing clay ware.

An examination of the country adjacent to the main line of the Canadian Pacific railway west to the Alberta boundary failed to discover workable clays. A large flat at Maple Creek is underlain by stoneless clay, but the material is a typical gumbo. It is sticky or excessively plastic and cracks badly in air-drying. When moulded in the dry-press way and burned the body produced from such material is punky and weak, with an excessive shrinkage.

Neville.

South of Swift Current, along the Vanguard branch of the Canadian Pacific railway near Neville station, a small coulée contains an exposure of Oligocene clay and clay silt. The material consists of light grey and reddish-brown interstratified calcareous clay and silt, the upper few feet being contaminated by limestone concretions. Below the concretion zone there is some twenty feet of clay and silt.

535. A sample of the lower twenty feet was made up into a full sized stiff-mud brick, but it failed to survive the drying test. A large quantity was then taken and mixed with 20% of sand and this mixture was pugged and put through a stiff-mud brick machine. Made into solid brick and hollow brick the mixture dried without cracking to a shrinkage of 4·0%. Burned in a range from cone 07 to 03 the brick were all good and sound and of a pink to brownish-red colour.

Treated with sand in amounts of 20 to 30 per cent this material will make a fair grade of face brick and hollow brick by the stiff-mud process. The location of the deposit along the railway near the town of Neville is very favourable, but no good sand occurs in the immediate neighbourhood.

Woodrow.

532. The flood plain of the Wood river near Woodrow contains a deposit of clay that looks promising in the field, but laboratory tests show it to be very defective in its drying properties. It cracks very badly even in very slow drying. Burned to cone 07 the colour is a good red. If a good deposit of sand could be located near hand it might be possible to work the clay by the soft-mud process, adding 25 to 30% of sand. The sample collected was too small to try this, but the addition of a large percentage of sand is mentioned as the only possible means of working the material.

Ponteix.

533. West of Woodrow near Ponteix a similar clay to that described above occurs in the flood plain of another branch of the Wood river. It cracks slightly in drying and would require the addition of 25% of sand to overcome this defect. A small amount of scum is present and barium salt would be necessary to overcome this.

Burned to cones 010 to 03 the colour of the body is a good red. By treating the clay as mentioned above and moulding it by the soft-mud process a fair grade of red common building brick could be manufactured.

CLAYS OF THE WOOD MOUNTAIN DISTRICT.

The central part of the Province along the international boundary is occupied by an elevation, a remnant of Tertiary rocks, known as Wood Mountain plateau. In its westward extension it consists of a narrow ridge, some fifty miles long and only a few miles across, forming the watershed between the waters of the Frenchman and the Wood rivers. To the east and northeast, the plateau descends and broadens, passing into the Coteau du Missouri. Its surface, particularly in the southern and western parts, is very rough cut by many short deep coulées of the Missouri drainage. The north facing side of the plateau is not as rough as the south slope and the descent to the plain is more gradual.

The abandoned river valleys of Big Muddy and Willowbunch lakes cut across the eastern part of the district in a northwest-southeast direction and in them are to be found the best exposures of Fort Union clays.

The Canadian Pacific railway crosses the Willowbunch valley near the south end of the Lake-of-the-Rivers and affords an outlet for the refractory clays of the vicinity of Willows.

The Canadian Northern railway, Bengough branch, is constructed as far west as Willowbunch lake but does not tap the clay resources. The proposed extension of this line westward crosses the Willowbunch valley, enters the Big Muddy valley near Willowbunch village and follows along the south side of Twelve Mile lake. South of this lake there are important exposures of refractory clays and valuable beds of lignite.

451. The western extension of Wood Mountain plateau, known as Pinto Horse butte, is well grassed and clay exposures are rare. On sec. 16, tp. 4, range 11, w. of 3rd. mer., a small exposure was found over a lignite seam. A four-foot bed of greyish-white sandy clay semi-refractory in character is the most important part of the section. Although limited in amount and located some distance from transportation it has a local value to the settlers for patching stove linings. Burned up to cone 9 (2390°F.) it has a total shrinkage of 10·0% and is not vitrified.

452. This material collected on sec. 24, tp. 3, range 10, w. of 3rd. mer., has the same interest as 451. It represents a 20-foot section of the white band which in this case consists of that thickness of sandy grey clay containing numerous lenses of iron-stained sand. Burned up to cone 7 (2320°F) it makes a good strong body with a total shrinkage of 8·0% and an absorption of 11·6%. It deforms at about 2600°F. (cone 15).

The sandy character and limited amount of the material constituting the white band in this part of the area is a contrast to the thick clay and sand sections found to the northeast and northwest. No trace of the white band was found in the Tertiary exposures to the east as far as Rocky creek in tp. 1, range 4, w. of 3rd. mer.

In a large coulée which cuts across the plateau through sec. 16, tp. 3, range 6, w. of 3rd. mer. two beds of Fort Union clays have been used by the settlers of the vicinity for adobe. These two beds, 453 and 453A, are rather conspicuous because of the contrasting colours blue-grey and yellow

453. This is a four-foot bed of clay, blue-grey in colour. It requires only 24% of water to work into a very stiff plastic mass. Small test pieces cracked badly in air-drying. Dry-press tests indicate a body of fair strength and a good light red colour at cone 06.

453A. A seven and a half foot bed of yellow clay overlies bed 453. Like most of the yellow fat clay beds of the Fort Union it is calcareou . The air shrinkage of 8% is not excessive but a 3″ block cracked in air-drying. Burned in a range from 010 to 06, the colour is a good red but turns pink to buff, approaching cone 1. Deformation takes place about cone 3.

These two clays are of small value from a ceramic standpoint because of the drying defects, but the tests serve to illustrate the character of the Fort Union clays in this part of the area.

Along the north slope of Wood Mountain plateau, across township 4, ranges 4 and 5, there are numerous exposures of lignite, and clays immediately associated with the lignite.

454. On sec. 11, tp. 4, range 5, two fairly thick beds of lignite are being worked by the open-cut method. The seams are separated by about 4 feet of grey clay and the future working of the lignite would be much more profitable if the clay could be mined and used in some way. The upper seam is overlain by a bed of yellow calcareous clay.

A sample of the grey clay requires 31% of water to attain maximum plasticity for working in the stiff-mud condition. Even with this large percentage of water the mass is stiff to work. Slow drying of full sized brick can be accomplished without cracking. The air shrinkage on the small test pieces amounted to 9·0%.

Burned to cone 06 the body is fairly hard and the colour a pleasing shade of pink. At this temperature the total shrinkage is 10·0 %. Deformation takes place at cone 5.

The total shrinkage of this material (stiff-mud) at the commercial burning temperature is excessive and better results were obtained with dry-press bricks. Samples moulded in the dry-press way burn to strong bodies with pleasing pink to buff colours in a range from cone 06 to 1.

This clay could be used along with the yellow clay which occurs over the upper lignite seam, for making a good buff dry-press face brick.

On sec. 1, tp. 4, range 4, w. of 3rd. mer., a thick seam of lignite is being worked in an open-cut along a small spring creek. It is overlain by a series of grey clays, silts, and thin lignite seams to a thickness of 10 feet.

Grey clay,	2 feet	Sample 456.
Lignite,	1½ "	
Blue clay,	4½ "	Sample 457.
Grey silt,	2 "	Sample 458.
Lignite,	5-6 "	

The materials of samples 456 and 457 crack badly in air-drying and the shrinkage is very excessive. No. 458 works up rather silty, but the small quantity indicated in the above section condemns it as a commercial material. When added to No. 457 in the proportions found in the bank the working qualities of the mixture showed little improvement over 457 alone.

The drying defects of these clays make them of no value from a clay-working standpoint.

At Henderson's lignite mine on sec. 16, tp. 4, range 4, w. of 3rd. mer., the section over the lignite is much the same as described at the locality of samples Nos. 456-8, except that the lignite is thicker and the grey clays above are thinner. Also the yellow silty clay on top is much thicker.

Yellow silty clay........................	8 feet	No. 459.
Grey clay..............................	½ "	
Lignite................................	2½ "	
Grey silty clay........................	½ "	
Lignite................................	9 "	

Sample No. 459, representing the 8 feet of silty calcareous clay at the top, develops excellent plasticity when worked with 26% of water. Drying can be carried on slow or fast without sign of checking, the shrinkage being 8·0%.

Burned in a range from cone 010 to cone 03 the body is of fair hardness and light salmon in colour. At cone 06 the total shrinkage is 7·0% and absorption 21·0%. Approaching cone 1 the colour changes to cream, and deformation takes place with cone 4.

This clay will make good common brick and field tile by the stiff-mud process.

Twelve Mile Lake.

North of Wood mountain in creek valleys cut through the Fort Union into the Pierre formation along Twelve Mile lake, there are numerous exposures of the white band.

284.[1] Sample is from one of the prominent white beds on the north escarpment of the Wood Mountain plateau. The sample was taken across a 7-foot seam. The material consists of a sandy clay of good plasticity and working qualities. It can be dried safely without checking after moulding, the shrinkage on drying being 5·5%.

Burned to cone 9 the colour is grey, the total shrinkage 8·5% and the absorption 12·0%. Deformation takes place at cone 14.

This material is only semi-refractory and could be used for making sewerpipe. If mixed with a clay fusing at a lower temperature a hard burned face brick could be made from it by either the dry-press or stiff-mud process.

Crossing secs. 22 and 27, tp. 5, range 3, w. of 3rd. mer., the white band outcrops in a north and south direction for some distance along a coulée. As in other exposures in this part of the area, the greater part of the section consists of greyish-white sandy clay as follows:—

Yellow silts	4 feet	
Thin lignite seam	1 „	
Sticky brown clay	8 „	
Greyish-white clay	4 „	No. 460.
„ „ sandy clay	3 „	No. 461.
Dark grey clay	3 „	No. 462.
Greyish-white sandy clay	30 „	No. 463.

Along the coulée the beds were noted to be very lenticular and the thick bed of sandy clay at the base varies from place to place in the content of clay. The thick bed of brown clay near the top of the section is very stiff and sticky, and hence was not sampled. There is a possibility that it may have some refractory value, and, when mixed with the rest of the section would make a good binder for the other rather sandy materials in the manufacture of sewerpipe or structural clay products, such as hollow building blocks.

460. This is a greyish-white clay having excellent moulding qualities when mixed with 22% of water. It dries well with a shrinkage of 7·6%. Soluble salts appear at the corners and edges of test pieces.

Burned to cone 06 the cream-coloured body is steel hard with a shrinkage of 9·0% and an absorption of 14·2%. At higher temperatures the colour changes gradually to a light grey and the body is nearly vitrified at cone 7, with a total shrinkage of 11·0%. The edges are fused due to accumulation of soluble salts in the drying process. Deformation takes place with cone 22.

461. Although this is a sandy clay it requires 28% of water to develop the maximum plasticity. Drying may be carried on with rapidity without fear of cracking, and, when complete, the shrinkage amounts to 7·6%. A minor amount of soluble salt is brought to the surface.

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[1]Sec. 15, tp. 5, range 4, w. of 3rd. mer.

Burned to cone 06 the white body has a total shrinkage of 8·3% and an absorption of 19·8%. At cone 9 the colour is cream-white, the total shrinkage is 12·0% and the absorption 12·0%. Although the body is not vitrified at this high temperature, it is hard and dense. It is the most refractory material in the section, deformation takes place with cone 27. It is too open burning to make sewerpipe but would make a fair grade of refractory brick.

462. This bed is contrasted with those immediately above and below by its dark grey or brownish colour and fat nature. It requires 32% of water to develop the best working consistency and at that it is rather stiff. However, drying was accomplished without difficulty with a shrinkage of 9·0%. No soluble salts were apparent.

Burned to the temperature of cone 06 the colour of the body is cream, the total shrinkage 12·0% and the absorption 17·8%. At cone 7 the colour has darkened slightly, the total shrinkage amounts to 16·6% and the absorption 7·2%. Deformation takes place with cone 20.

463. The lowest bed in the white band is not wholly exposed but the part in sight is a very sandy clay. It requires 24% of water to work it and the limits between the stiff-mud and soft-mud consistencies are very narrow. Drying is quite safe with a shrinkage of 7·0%, but large amounts of soluble salts come out on the edges and, in burning, cause fusion.

Burned to cone 06 the total shrinkage amounts to 7·0%, the colour of the body is a dirty cream, and the absorption 13·2%. Although a very sandy material it appears to burn fairly dense at low temperatures, and the density is not much increased up to cone 9.

Burned at the temperature of cone 7 the body is cream in colour, the edges being fused and discoloured by the presence of the soluble salts; the total shrinkage amounts to 9·0% and the absorption 10·5%. Deformation accompanies the bending of cone 22.

These four clays (460-63) are all semi-refractory, except perhaps No. 461, which is equal to a No. 3 fireclay. A straight mixture would be too refractory for sewerpipe manufacture and not refractory enough or a good firebrick. However if a small percentage—25%—of the less refractory yellow clays of the vicinity be added to the mixture a very good face brick or hollow ware body would result.

Similar sections to the one described above occur on sections 20, 21, 29, and 30, tp. 5, range 2, w. of 3rd. mer.

East of Wood Mountain P.O., along the valley of Hay Meadow creek, a small exposure of the white band was found on sec. 23, tp. 4, range 3, w. of 3rd. mer. It occurs in the north bank of the valley at an elevation about 100 feet above the creek bed. Eastward along the valley a few small outcrops of the white clays were noted, but the sections were not very thick, usually amounting to only four or five feet of rusty white clay.

Near the east end of Twelve Mile lake on sec. 9, tp. 6, range 1, w. of 3rd. mer., a ten-foot bed of greyish-white sandy clay outcrops at the waters edge (see Plate IX). Rose[1] describes a sample collected from this locality in 1914, No. 286, but the results of the tests indicate either a restricted sample or one from a distinctly different part of the outcrop sampled in 1916.

286. This is a white clay of sandy texture, resembling 284, but not quite so sandy.

It requires 27% of water to bring to the best working consistency. The shrinkage in drying is 6·5%. This clay will have to be dried slowly to avoid checking.

The results obtained in burning were as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour.
1	2·3	10·9	White
3	3·0	9·0	"
5	3·0	8·7	Grey
9	3·0	7·4	"
13	Softens.		

The following section was measured in a butte where the sample was taken in 1916:—

Sticky grey and yellow clays.............17 feet
Grey sand.............................3 "
Greyish-white sandy clay................10 " No. 466.

466. This is a greyish-white, sandy clay requiring 26% of water to mould in the stiff-mud condition. Very little more (2%) water is needed to make it the right consistency for working by the soft-mud process. The sandy nature of the material would be very hard on a stiff-mud machine and die so this material would be best adapted to the soft-mud process.

Drying can be accomplished without difficulty and results in a shrinkage of 8·0%. Minor amounts of soluble salts appear at the edges and corners but do not appear to affect the refractoriness of the material.

Burned to the temperature of cone 06 the total shrinkage is 7·3%, the absorption is 16·0% and the body has fair strength. At cone 7 the total shrinkage is 11·0% and the absorption is 10·5%. This is practically the condition at cone 9. Deformation takes place with cone 28.

The siliceous nature of this clay keeps the shrinkage low, particularly at the lower temperatures. It has a value as a No. 3 grade refractory, and as such could be used to advantage in making soft-mud firebrick, or for making a buff or flashed face brick.

In a coulée crossing secs. 1 and 2, tp. 6, range 2, w. of 3rd. mer., the white band is quite thin and contains considerable quantities of soluble salts. Thick beds of dark coloured gumbo clays immediately overlie it and

[1]B. Rose, G.S.C., Memoir 89 p. 77.

contain a workable seam of lignite. A dark grey clay forms the roof of the lignite bed and a sample (No. 464) was collected and the tests may be summarized as follows:—

464. This is a very stiff working clay requiring the large amount of 34% water to obtain a maximum plasticity for moulding stiff-mud. Soluble salts appear in air-drying and the shrinkage is 10·0%. It will not stand fast drying.

In burning, the test pieces all show cracking and although the colour of the body is a fair red, a bad scum spoils it. Dry-press pieces check very badly in burning.

The defects of this material are too great to make it of value to the clay-worker.

Eastward along this vicinity, near Mullraney P.O., the white band is not seen and the elevations indicate that it pinches out in this vicinity.

[1]Rose collected two samples in this vicinity from beds immediately overlying coal seams.

173. A coal seam in the valley side on sec. 12, tp. 6, range 29, w. of 2nd. mer., is overlain by a 10-foot bed of yellowish-grey silty clay. It requires 25% of water for tempering. It will stand fast drying with artificial heat, the drying shrinkage being 5·5%. It burns to a porous salmon-coloured body at cone 06 and deforms approaching cone 6. It is suitable for the manufacture of common building brick.

174. This is a dark grey clay shale occurring over a coal seam on sec. 6, tp. 6, range 29, w. of 2nd. It requires the extraordinary amount of 44% of water for tempering and is very stiff to work. The drying shrinkage of 10·0% is excessive and cracking results. These defects make it of little value for the manufacture of clay products.

465. On the north side of the valley in sec. 13, tp. 6, range 30, w. of 3rd. mer. a very thick section of the Fort Union beds is exposed to view. About 50 feet from the top there is a heavy bed of greenish-grey clay in which occurred several lenses of fine grey sand. Sample No. 465 was collected in a trench cut for 20 feet up the face.

This is a greenish-grey to yellow clay, very plastic in its working qualities. Only 21% of water is required to mould it in the stiff-mud condition. The air shrinkage of 9·0% is on the verge of being excessive, but a large block dried safely in a moist atmosphere.

It burns to a strong body of a salmon colour at cone 010, but a heavy white scum obscures the colour of the body.

The high shrinkage and the scum are serious defects, sufficient to make this material of doubtful value for the manufacture of clay products.

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[1]Rose (G.S.C.) Memoir 89, p. 76

Willowbunch.

To the southeast, along the Twelve Mile Lake branch of the Big Muddy valley, exposures of clay, similar to those described near Mullraney P.O., are to be found in coulées tributary to the main valley. Most of the beds have serious defects such as cracking in air-drying and scumming. The most promising beds occur in the upper part of the section. No exposures of the white band clays were noted between Mullraney and Willowbunch village but small outcrops were found at the head of a large coulée to the southwest of Willowbunch on or about sec. 22, tp. 5, range 28, w. of 2nd. mer. A section measured from the top of the bank downward to the grass covered part of the slope resulted as follows:—

Glacial boulder clay..................	6 feet	
Fat yellow clay containing selenite	8 "	
Fine grey clay..................	10 "	No. 492.
Light grey sandy clay containing many iron oxide concentrations	25 "	
Purplish-grey clay..............	2 "	
Yellow sand....................	3 "	

The most likely looking part of this section is the 10-foot bed of grey clay and tests on the material bear this out.

492. Sample of the ten-foot bed described above. It works up into a body of excellent plasticity with 27% of water. It is very smooth and easy to work. Drying slow or fast is accomplished without cracking, the shrinkage being 8·6%.

Burned to the temperature of cone 06 the total shrinkage amounts to 9·3%; the body is cream-coloured and of fair hardness. The absorption is 16·4%. At higher temperatures the colour remains much the same to cone 7, about which temperature it changes to a light grey. Vitrification takes place between cones 7 and 9, and deformation follows at cone 16.

This is a good semi-refractory clay of the stoneware type and could be used for any of the purposes to which a stoneware clay is put.

CLAYS OF THE MAIN BIG MUDDY VALLEY.

Southeast from Willowbunch village along the south branch of the Big Muddy valley to the vicinity of Big Muddy lake, the outcrops of the white band are most prominent along the north side of the valley. It is very irregular in thickness and changes rapidly from place to place in the character of its material. All the white clay outcrops in the valley from Willowbunch to Big Muddy lake are characterized by the presence of considerable quantities of soluble salts, which, in dry weather appear as white featherlike crystals coating the outcrops of the more sandy beds. The clay part of the white band is particularly rich in soluble salts, and, where sampled, it was found to be very sticky in its working qualities and difficult to dry without cracking.

172. This is a greyish-white gritty clay collected by Rose from an exposure on sec. 31, tp. 3, range 24, w. of 2nd. mer. It requires 24% of water for tempering and is very plastic, stiff and pasty in the wet state. It dries very slowly and exudes soluble salts. Small test pieces do not crack in drying but large pieces probably will. The air shrinkage is 7·0%.

The burnt colour is pink at all temperatures up to cone 5. The body is vitrified at cone 9 and deforms around cone 20.

This material could be used in a mixed body for making sewerpipe, face brick, fire proofing, etc., by the stiff-mud process or could be used alone for making face brick by the dry-press process, burning of the ware being carried to cones 1 to 3.

Two samples were collected by Rose from two thick beds of the Fort Union overlying the white band on this section Both proved to have serious defects in drying and burning, sufficient to render them of no value to the clayworker.

This part of the valley is characterized by numerous burnt clay outcrops where lignite seams have been on fire and baked the overlying and underlying clay. Practical use is being made of this sort of material for surfacing muddy roads. A considerable quantity has been used in the village of Willowbunch for this purpose. Up a large coulée, tributary to the main valley, near Waniska P.O., beds of clay as much as 20 feet in thickness have been completely dehydrated and baked in this way. Near the head of this coulée several openings have been made for lignite, and near one of these, at the south end of Coal Mine lake, Mr. Rose[1] collected two samples of clay. The tests on these were reported as follows:—

179. "Sample is from a sandy clay or yellowish-coloured silt underlying 179A. When tempered with 25 per cent of water, it forms a body of rather low plasticity, which is short in texture. The drying shrinkage is 6 per cent and it probably dries without cracking. Burning tests, cone 06, percentage of fire shrinkage 0; percentage of absorption, 19·0; colour, light red. This clay appears to be suitable for the manufacture of common brick, although the drying qualities would have to be further tested on a large scale."

179A. "Sample is from a grey shaly clay which occurs in a 2-foot seam, below the coal at Coal Mine lake. This clay forms a highly plastic, stiff and sticky mass when wet, and will probably crack in drying. It burns to a hard red body at cone 06, with a total shrinkage of 12%, which is excessive. The burned body is badly scummed. This clay is of little value and is not recommended for brick making purposes."

A number of the thickest beds in this vicinity were tested in the field for drying behaviour and all showed excessive shrinkage, cracking and scum.

Big Muddy lake occupies a depression that is partly due to the cutting

[1]Rose: Memoir 89, G.S.D. p. 75.

PLATE VIII

Outcrop of white fireclays exposed on sec. 9, tp. 6, range 1, w. of 3rd. mer., Twelve Mile lake, Sask.

PLATE IX

Estevan, Whitemud, and Ravenscrag beds of the Fort Union formation, exposed in the badlands west of Big Muddy lake, Sask.

of the main valley and partly to an intermorainal depression in the moraines to the east of the valley.

To the south of the main body of the lake immense thicknesses of sand, silts, and clays of the Fort Union are exposed in the deep coulées of the badlands. Here are to be found beds of the three divisions of the Fort Union. The Estevan beds form the greatest part of the section, the Whitemud beds being near the top of the valley sides.

Magnificent exposures are to be seen near Kehoe's ranch in tp. 2, ranges 22 and 23, w. of 2nd. mer. Also in Carlyle and Huntley coulées to the east and west of Big Muddy (See Plate IX).

On or about the N.W. ¼ sec. 30, tp. 1, range 22, w. of 2nd. mer. in Huntley coulée, the following section was measured and the most important beds sampled:

Top	Yellow silt	20 feet + or −	
	Yellow silty clay	8 "	Sample 493
	Yellow silt and sand	3 "	
	Hard yellow limestone	1 "	
	Purplish-grey clay......	4 "	Sample 495
	Greyish-white sandy clay	4 "	Sample 496
	Yellow clay full of iron oxide concretions	1 "	
	Greyish-white plastic clay	5 "	Sample 497
	Greyish-white sandy clay	2 "	
	Talus		

Some two thousand feet away in another outcrop the clay beds (496 and 497) near the base of the section given above are merged into one bed about 7 feet thick.

493. This is a yellow silty clay, requiring 27% of water to attain maximum plasticity for working in the stiff-mud condition. It can be dried with safety by either natural or artificial means. The air shrinkage amounts to 6·0%.

Burned to the temperature of cone 06 the body is salmon-coloured, the total shrinkage is 6·0% and the absorption 23·1%. At cone 1 the body is buff in colour, shrinkage increases to 8·0% and the absorption decreases to 12·6%. Deformation takes place at cone 5. The colour of the body, at all the temperatures used, is largely obscured by a white scum.

This material could be used for making common backing brick burned at any temperature from cone 010 to cone 1.

495. The top bed of the white band is purplish-grey clay, weathering white on the surface. It develops excellent plasticity when wetted with 23% of water and dries safely with a shrinkage of 7·0%.

Burned to cone 06 the body is cream-coloured, the total shrinkage is 7·0% and the absorption 13·8%. Little change is apparent up to cone 7, at which temperature the shrinkage is 8·0% and the absorption 11·1%. Deformation takes place at cone 20.

The most valuable use to which this material might be put, should local conditions warrant it, would be for making face brick or structural hollow ware.

496. A four-foot bed of white silty clay underlies 495. It requires but 21% of water to develop a rather silty plasticity and dries safely with a shrinkage of 6·6%.

Burned to cone 06 the body is fairly hard and cream-coloured. Pieces burned at this temperature have a total shrinkage of 6·6%, and an absorption of 14·9%. At higher temperatures the colour darkens slightly, and vitrification is not complete at cone 9, the absorption being 5·1%. Deformation takes place with cone 26.

This is a refractory material of a No. 3 grade.

497. The thickest bed of the white band here consists of a greyish-white plastic clay. It requires as much as 30% of water to develop a rather sticky type of plasticity. Drying can be accomplished with care, but the shrinkage of 10·0% is excessive.

When burned to cone 06 the body is cream-coloured and of good strength, the total shrinkage being 11·6% and the absorption 12·6%. Vitrification is complete at cone 7 with a total shrinkage of 14·3%. Deformation takes place with cone 13.

This is a fair grade of stoneware clay but because of its sticky nature could not be used alone. Mixed with the material of beds 495 and 496 and a suitable amount of grog to reduce the shrinkage, an excellent sewer-pipe body could be made, to make a salt glaze in a range from cones 5 to 7.

In the bald buttes around the sides of Carlyle coulée the white band is seen to thicken and thin out from place to place, and, in small tributary coulées towards the international boundary, its place is largely taken by a thick bed of yellow to grey sand.

Up the coulée on sec. 7, tp. 1, range 21, w. of 2nd. mer., the white clay band is quite thick and the exposure consists of the following:—

Top—Yellow silts	8 feet	
White clay full of iron concretions	5 „	
Dark grey clay	8 „	
Grey carbonaceous silt	5 „	
Grey plastic clay	9 „	Sample 498

498. This is the thickest and most continuous bed of the above described section and consists of 9 feet of a plastic grey clay. Mixed with 30% of water it develops excellent plasticity for working in the stiff-mud way. Drying the ware made from it can be carried on safely but the shrinkage of the clay alone, 10·0%, is rather excessive.

When burned to cone 06 the total shrinkage of 13·0% is excessive. Vitrification takes place at cone 3 with a shrinkage of 15·3% and deformation follows with cone 12.

PLATE X

Pit of the Alberta Clay Products Company, near Willows, Sask.: showing section of fireclay worked for sewerpipe.

PLATE XI

Fireclay outcrops, along Canadian Pacific Railway, east of Willows, Sask.

Although the shrinkages of this clay in drying and burning are excessive the defect could be taken care of by the addition of grog Mixed with the other materials of the section below the yellow silt, it would make excellent face brick, and with the proper amount of grog to take care of the excessive shrinkages it could also be used for making sewerpipe, burned and salt glazed in a range from cone 1 to cone 5.

499. In the badlands to the north of Kehoe's ranch and approximately on sec. 12, tp. 2, range 23, w. of 2nd. mer. the white band consists of a single bed of white plastic clay some 20 feet thick.

A sample of this clay requires 31% of water to mould in the stiff-mud condition and the working properties are excellent. Open air-drying of test pieces and a full sized brick can be accomplished without cracking, the shrinkage being 8·3%.

Burned to cone 03 the body is cream-coloured, and steel hard, with a shrinkage of 11·3%, and an absorption of 11·8%. Vitrification takes place around cone 7 with a shrinkage of 16·6%. Bloating of the body is apparent at cone 9 and deformation follows with cone 12.

Material of this sort could be used for making high grade face brick, hollow ware, or sewerpipe.

CLAYS OF THE LAKE-OF-THE-RIVERS DISTRICT.

Willows.

The Canadian Pacific railway crosses the Lake-of-the-Rivers valley near Willows, and in this vicinity close to the railway there are large exposures of the white band clays. For several years the Alberta Clay Products Co., of Medicine Hat (see Plate XI) has been mining clay in the northeast bank of the main valley on sec. 1, tp. 8, range 29, w. of 2nd. mer. This material was shipped to Medicine Hat and used as a whole, and later as a part, in their sewerpipe body.

The section exposed in the pit is as follows:—(See Plate X).

Top—Thin covering of boulder clay	2	feet	
Sticky dark grey clay with selenite	4	"	
Lignitic clay	1	"	
Purplish-grey clays	15	"	No. 474.
Lignitic clay	½	"	
Dark grey clay	3	"	
Light grey sandy clay	4	"	
Purplish-grey clay	5	"	No. 475.
Grey clayey sand	3	"	
Bottom—Carbonaceous sandy clay	2	"	
Floor—Dark grey clay, much selenite.			

The upper part of this section, where observed in the district, is distinctly clayey, while the lower part is quite sandy. The run-of-bank is not quite vitrified at cone 10 and consequently burning sewerpipe made from it is a rather costly process. During the past year the stoneware clays of the vicinity of Eastend have been mined and shipped to Medicine Hat to be mixed with the Willows clay. A better sewerpipe has resulted from this mixture and the burning temperature has been reduced to cone 7.

474. The most important part of this bank is the fifteen-foot bed of purplish-grey clays near the top. Examined in the laboratory a sample of this material was found to consist of a very strong plastic clay of fair purity. Washed through a 150 mesh screen only 1% remained on the screen. The residue consisted of iron oxide replacements of plant forms and a few clear quartz grains.

When moulded with 31% of water the resultant plasticity is excellent and drying the pieces can be accomplished without checking, although the addition of grog would materially assist in the drying. Without grog the air shrinkage amounts to 8·3%. It has all the properties of a good bond clay.

When burned to cone 03 the colour is a good white, the total shrinkage 12·6% and the absorption 16·0%. The test pieces developed fire checks at all temperatures to which they were burned up to cone 9. The body remains a good white colour and is not vitrified at cone 9. In these respects it acts very much like a ball clay and the similarity is extended further to the deformation temperature of cone 30.

Analyses of Clays from Willows, Sask.

	474.	474W.
SiO_2	58·28	56·[illegible]2
Al_2O_3	26·07	27·89
Fe_2O_3	1·61	1·75
FeO	·18	·18
CaO	·68	·96
MgO	·34	·21
K_2O	·32	·59
Na_2O	1·14	[illegible]·73
CO_2	·10	·1[illegible]
H_2O	12·02	10·40
	100·74	100·30

475. The next most important bed in this section consists of a purplish-grey fat clay which acts in many respects like number 474. It requires 26% of water to develop maximum plasticity and dries to a very strong body with a shrinkage of 8·3%.

Burned to cone 03 the colour is a dark cream, the total shrinkage is 10·3% and the absorption 11·9%. At cone 9 the total shrinkage is 13·3% and the body is not quite vitrified, the absorption being 4·5%. Deformation takes place at cone 22 indicating an open burning semi-refractory clay suitable for face brick, as part of a sewerpipe mixture, or for stove linings.

The remaining beds of the section are sandy clays or clayey sands in which the coarser material is principally angular quartz grains. When these beds are mixed with the rest of the section the refractory value is about cone 28 or a number three grade of refractory.

On sec. 33, tp. 7, range 28, 2nd. mer., about six hundred feet south of the railway, an exposure of some twenty feet of white clay is to be found. The proportion of good plastic clay in it makes it one of the most important outcrops in the district. A measured section resulted as follows:—

Top—Thin covering of boulder clay.............			
Yellow silty clay (calcareous).............	6	feet	
Purplish-grey clay....................	10	„	No. 476.
Greyish-white clay......................	2	„	No. 477.
White clay.............................	7	„	No. 478.

This is further illustrated in Plate XI.

476. The top clay of the white band is purplish-grey in the fresh cut bank, but weathers greyish-white on the weathered surface. It is a very plastic material requiring 32% of water to temper it to a stiff-mud consistency. Drying of ware made from it can be accomplished without cracking, the shrinkage being 8·3%. Soluble salts in minor amounts appear at the corners of test pieces.

When burned to cone 03 the total shrinkage amounts to 13·0% and the absorption 16·5%. The burnt colour is a poor cream-white. At higher temperatures up to cone 9 the colour remains cream-white, but dark fused spots caused by iron oxide impurities are prominent at cone 5. At cone 9 the total shrinkage is 18·3% and the absorption 3·8%. Deformation takes place with cone 28, indicating a body of No. 3 refractory grade.

The excessive shrinkage of this material in burning caused it to crack badly at all temperatures to which it was burned. Like the other high grade clay of the district it is a good bond clay and must not be used alone.

A washing test on this material produced 15% of material that would not pass a 200 mesh screen. The residue consisted of fossil plant forms, fruits and stems hardened by replacement by iron oxide, minute iron oxide concretions, and fine quartz sand grains.

476W. The washings were hard to settle and appeared to consist of a large proportion of colloidal clay matter. When settled, dried and reground it required the large amount of 35% of water to develop a rather sticky type of plasticity. Drying of small pieces can be accomplished without checking but large pieces crack. The air shrinkage of 8·3% produces a body of great tensile strength.

Burned to cones 5 and 7 the colour is a clean cream-white and the body steel hard but not vitrified. Deformation takes place with cone 30, showing an improvement over the unwashed material of two cones.

477. The bed immediately below 476 is much thinner, and slightly lighter in colour. It also contains iron oxide concretions finely disseminated, and which appear in the burned test pieces as fused specks above cone 1.

The clay works up to a mass of excellent plasticity with 20% of water. Drying of the test pieces is accomplished without cracking, the shrinkage being 8·3%; the body has a very high tensile strength.

Burned to cone 03 the body is cream-coloured and steel hard with a total shrinkage of 13·3% and an absorption of 10·9%. At cone 5 the total shrinkage is 14·6% and the absorption 8·5%. At cone 7 the shrinkage increases to 17·0% and the body is vitrified A slight swelling takes place at cone 9 and complete deformation accompanies cone 27.

This material in the raw state is a fair grade of refractory and its greatest use would be as a bond clay with a more refractory grog.

477W. A sample of 477 was washed and screened. The residue, 8%, on 150 mesh sieve consisted of fine angular quartz grains and minute iron oxide concretions with a few lumps of selenite. A few muscovite mica scales were noted also.

The washed clay requires 35% of water to mould it in the stiff-mud condition and develops a rather stiff type of plasticity. The air shrinkage of 10·0% is excessive but the dried body has great tensile strength.

Burned to cone 7 the total shrinkage amounts to 17·6%; the body is cream-white, steel hard, but not vitrified, the absorption being 8·9%. Washing improves the refractoriness of this clay, the deformation temperature being advanced from cone 27 to cone 29.

478. The lowest bed of the white band exposed in this section consists of some 7 feet of white plastic clay. It requires 31% of water to develop an excellent plasticity. The test pieces dried without checking to a shrinkage of 8·0%. Soluble salts in minor amounts are brought to the surface in the drying out of the water, but no trouble is given by this scum in subsequent working except to influence the deformation temperature.

Burned to cone 03 the total shrinkage is 11·0% and the absorption 14·6. The burnt colour is dark cream. Above cone 1, impurities, in the form of minute iron oxide concretions, show up as fused spots in the brick. At cone 9 the total shrinkage is 15·3% and the body is not quite vitrified, the absorption being 6·7%. Deformation takes place with cone 22.

478W. A sample of 478 washed in the laboratory washer yielded 16% residue in the tank, 14% residue in the pan, and 70% of washed clay. The residues consisted of sandy material, including fine angular quartz particles, concretionary iron oxide grains, and a few white mica scales.

The washed clay when dried and ground requires 31% of water to develop an excellent plasticity. The drying shrinkage of 9% is on the verge of being excessive but no checking was observed in the test pieces. Burned to cone 5 the total shrinkage is 15·0% and the absorption 12·1%.

Two cones higher the shrinkage is 17·0% and the absorption reduced to 3·7, practically vitrification. The refractoriness of the washed clay is increased over the unwashed material by 8 cones, deformation taking place with cone 30.

About two miles west of the above described locality and on sec. 30, tp. 7, range 28, w. of 2nd. mer., a large coulée tributary to the main valley shows a much more complete section of the white band. The section measured as follows:—

Top, thin covering of boulder clay........		
Yellow sand, and silty clay...............10 feet		
Sticky brown clay with selenite present ...16	„	
Alternate grey clay and sandy clay bands..12	„	No. 467.
Carbonaceous clay and lignite............ 1	„	
Light grey clay.......................... 2	„	No. 468.
Yellowish-grey clay...................... 3	„	No. 469.
Dark grey clay........................... 6	„	No. 470.
Purplish-grey clay....................... 3	„	No. 471.
Greyish-white clay....................... 5	„	No. 472.
Silt..................................... 1	„	
Alternate silty grey clay and sand bands..20	„	

It will be noted that this section is somewhat different in the number and variety of beds from the other outcrops in the vicinity.

Working into the bank at this exposure would require the removal of considerable overburden should the material be required for refractories, but the quality of good clay available would well repay its removal.

467. The top bed of the series consists of some twelve feet of greyish clay containing a few thin silty clay bands or lenses. It requires 26% of water to temper it and the resultant plasticity is excellent. The drying properties are good and the dried body has a high strength although the shrinkage of 10·0% appears excessive. At all temperatures to which the test pieces were burned they fire checked very badly due to an excessive fire shrinkage. At cone 010 the total shrinkage is as high as 12·6%. Deformation takes place with cone 31, indicating a refractory of No. 2 grade.

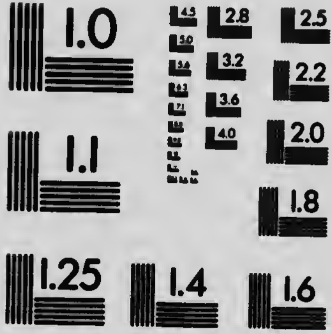
The one important result brought out in the tests and not mentioned above is the good white colour of the burned body at all temperatures at which the tests were burned, up to cone 9.

This clay has a value as a white-burning bond clay for making cheap earthenware, as well as for making face brick and refractory shapes such as firebrick, glass pots, retorts, etc.

468. A thin lignite seam separates this bed from 467 above. The clay is light grey in colour and contains a relatively large percentage of fine sand. When moulded with 26% of water the plasticity is of a sticky nature, and even with the large content of sand, small test pieces cracked

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



in air-drying. It is a very low grade clay to be found in such association. Deformation takes place with cone 5. This material has no value used alone but could be mined with the rest of the section for manufacturing face brick. It would have to be avoided in making refractories.

469. This is a yellowish-grey clay which develops a stiff type of plasticity when tempered with 30% of water. Drying is safe by slow means but the air shrinkage of 9·0% is on the verge of being excessive. At all temperatures to which the tests were burned the pieces were badly cracked because of a further excessive shrinkage in the fire. However, it has good refractory properties, not deforming under cone 30.

470. The thickest bed in the lower part of the section consists of six feet of purplish-grey clay. Tested with acid it is found to be slightly calcareous. Tempered with 28% of water it works up into a stiff plastic mass and test pieces made from it dried without checking to a shrinkage of 8·0%.

As with the other beds in the section the strong character of the clay base causes an excessive fire shrinkage with resultant fire checking. At cone 03 the total shrinkage is 12·0% and the absorption 15·6. At the lower temperatures the colour is a dirty cream which changes to grey near the vitrifying point. About cone 7 the total shrinkage amounts to 17·0% and vitrification is nearly complete. Deformation follows at cone 29.

The fact that this material cracks badly in firing throws it out of consideration as a clay to be used alone. It would require considerable grog to work and dry it when using the stiff-mud process for the manufacture of firebrick.

471. This is a purplish-grey clay in a bed three feet thick. It requires only 24% of water to temper to a very excellent plasticity. The air shrinkage amounts to 6·6%.

Burned to cone 03 the colour of the body is a good cream-white, the total shrinkage is 9·0 and the absorption 15·5%. At higher temperatures the body keeps its cream-white colour but shows a few fine-grained iron spots. Burned to cone 9 the total shrinkage is 16·0% and the absorption 5·1%, but little change from the results of cone 7. Deformation takes place with cone 30.

472. The lowest distinctly clayey bed exposed in the section consists of five feet of greyish-white clay. It works up to a very smooth plastic mass with 26% of water, and resembles a stoneware clay in working qualities. No defects occur in drying, the shrinkage of 7·6 being within practical limits.

Burned to cone 03 the body is cream-coloured, has a total shrinkage of 10·0% and an absorption of 12·4%. Vitrification is practically complete at cone 7 and there is little change to cone 9. At the latter temperature the total shrinkage is 14·3. Deformation takes place with cone 22.

In working this section of clays for refractories there would be a total thickness of about thirty feet available. Beds 467, 469, 470, and 472 are individually No. 2 refractory grade, and 472 is semi-refractory. These beds mixed in the proportions found in the bank have a refractory value of cone 29. Bed 468 below the thin lignite bed is red-burning and not refractory. It is only 2 feet in thickness and most of it could easily be thrown aside in mining the clay.

For making face brick a great variety of shades and textures could be obtained by mixing in various percentages up to 50% of the overlying red-burning clays and moulding by the dry-press process direct. To make clay ware in the stiff-mud way at least 30 per cent of grog would be necessary to reduce the shrinkage and avoid fire checking.

The situation of this material near Willows station and within one quarter of a mile of the Canadian Pacific railway makes it of particular value as a clayworking location. The bottom of the coulée in which it occurs is wide enough to permit the location of a fairly large plant at an elevation such that gravity haulage could be used from the pit to the plant. A siding of about half a mile would be required to the railway.

About a mile west of Willows station a deep coulée shows about 15 feet of very sandy, white clay. Some of this material was shipped to Medicine Hat, but was found to be too gritty and refractory to use in the sewerpipe body. This sandy clay is overlain by a thin covering of yellowish-brown silty clay and boulder clay.

479. The yellowish-brown silty clay looks to be a promising material for making common brick and to this end a thicker deposit of it was located and sampled on the north side of a coulée on sec. 3, tp. 8, range 29, w. of 2nd. mer. The material has excellent plasticity but drying tests show the clay to crack in large pieces, although the shrinkage of 7·0% is not excessive. However, the cracking can be cured by the addition of 25% sand.

Burned to cone 010 the colour is an excellent red with but a faint indication of scum. The total shrinkage is 6·4% and the absorption 13·5%. At cone 06 the red body is at its best. It is hard and strong with a shrinkage of 7·0% and an absorption of 13·3%. Deformation takes place with cone 5.

Made into dry-press bricks the body is good at cone 03, the colour being a deep red.

This material is one of the best red-burning clays of the whole area. With grog it will make good stiff-mud or soft-mud brick and the dry-press body indicates promising results for brick. It flowed very smoothly from the die and three-inch drain tile made from it dried and burned without sign of defect.

Southeast from Willows past Readlyn towards Verwood the white band thins and is represented by sand and a very sticky greyish-white clay very much contaminated by soluble salts.

Viceroy.

On Willowbunch lake south of Viceroy on sec. 35, tp. 5, range 22, 2nd. mer., two thick beds of clay above a coal seam were sampled as follows:—

Top,	Yellow-grey clay silt (calcareous)	30 feet	No. 489.
	Dark grey clay	15 „	No. 490.
	Lignite	6 „	

The lower bed was sampled by Rose in 1912 and, when tested, it was found to be red-burning, but the shrinkage was excessive. A large sample of this material made up into full sized dry-press bricks with the minimum of water showed more clearly the excessive shrinkage and the resultant fire checks.

The upper bed is more promising. It is a calcareous clay requiring 26% of water to mould in the stiff-mud condition. Drying can be accomplished without checking, although the material must be considered tender in this respect. The drying shrinkage is 8·3%.

Burned to cone 03 the body is hard and of a salmon colour; the total shrinkage being 8·3% and the absorption 16·8%. Deformation takes place with cone 3.

Made up in the dry-press way the ware requires to be burned to cone 02 to 1 to get good results. In this way it will make a good buff face brick.

Mitchellton.

Between the north and south ends of the Lake-of-the Rivers there are no exposures of clays, the banks being well grassed. Near the forks in the north end of tp. 10, range 28, W. of 2nd. mer., the white band outcrops at the water's edge on the W. ½, sec. 27, tp. 10, range 28. In this outcrop the material is a sandy white clay, no real plastic fat clay being noted. Along the west shore to the north more exposures of similar material were found on N.E. ¼ sec. 33, tp. 10, range 28, and on sec. 3, tp. 11, range 28. The most prominent exposures are to be found on sec. 14, tp. 11, range 28, on the east side of the valley at the junction of a tributary coulée. At this point the following section was measured:—

Top,	Thin covering of glacial drift	5 feet	
	Yellow silty clay	5 „	No. 480.
	Yellow and grey silt	6 „	
	White sandy clay	12 „	+ No. 481.

480. This is a yellow calcareous clay which appears silty in the dry state but when tempered with 28% of water it develops a slightly sticky type of plasticity. A full sized brick cracked in air-drying.

Burned to cone 06 the body is hard and of a good red colour but on standing it becomes disrupted by the popping of lime particles. The shrinkage at cone 06 is 9·0% and the absorption 15·8%. The drying and burning qualities of this clay make it a poor clayworking material. It is too silty to work dry-press and the presence of lime grains would reduce its value for face brick.

A mixture of 50% sample 480 and 50% sample 481 gave better drying results, but the resultant colour is not a good red. However, the mixture would make good common soft-mud brick or possibly stiff-mud brick. Further testing on a larger scale would need to be done, particular attention being paid to the drying stage.

The mixture has an air shrinkage of 7·0%. At cone 06 the body is hard and salmon-coloured, with a shrinkage of 7·0% and an absorption of 14·0%. Deformation takes place with cone 8.

481. The lower bed consists of a greyish-white sandy clay which requires 25% of water to temper to the stiff-mud consistency. It dries without difficulty either slow or fast to a shrinkage of 6·0%.

Burned to cone 03 the body is fairly hard and cream-coloured. The total shrinkage is 6·6% and the absorption 12·7%. Little change takes place in the body up to cone 9, at which temperature the total shrinkage is 7·0% and the absorption 11·3%. Deformation takes place at cone 28.

An analysis of a sample from this bed made by W. S. Bishop, at the University of Toronto, for the Consumers Coal Co., resulted as follows:—

SiO_2	66·30
Al_2O_3	19·02
FeO	5·10
CaO	0·11
MgO	0·60
Loss on ignition	7·29

This is a refractory clay of No. 3 grade. Its working properties are good and it could be used for making firebrick or face brick, by either the soft-mud, stiff-mud, or dry-press process. A variety of colours could be obtained for face brick by mixing in various proportions of the overlying red-burning clay and flashing. It would also make fireproofing, flue lining, and wall coping.

The Consumers Coal Co., of Moosejaw, have a lignite mine, worked intermittently, on sec. 36, tp. 10, range 28, w. of 2nd. mer. In the open-cut along the coulée across this section two thick beds of clay were sampled a[illegible] the coal.

482. This is a dark grey clay in an 8-foot bed immediately above the coal. It works up to a very stiff sticky mass with 38% of water. The air shrinkage is excessive and test pieces crack badly. Scum also appears and masks the red colour of the burned samples.

Made up in the dry-press way and burned to a strong body the shrinkage is excessive and there is a tendency to fire check. It is of doubtful value for clay ware.

483. The upper bed consists of 6 feet of grey calcareous clay. It cracks badly in air-drying and, when moulded in the dry-press way, burns to a porous buff body with a tendency to fire check. Both these clays, 482 and 483, are highly colloidal and consequently have high shrinkage. They have no value for making clay ware in the ordinary processes, but with lignite handy as a fuel they might be made workable by subjecting them to a preheating treatment.

484. On the S.E. ¼, sec. 33, tp. 10, range 28, w. of 3rd. mer., a new coal mine has been opened and the roof of the coal is a six-foot bed of grey clayey sand. It has been stated by the owners that this material has a value as a moulding sand, but it is too clayey to be of use in that way. However, it has a value as a soft-mud brick material, if it can be mined cheap enough for this process. It has fair plasticity (sandy) when moulded with 27% of water and dries to a fairly strong body with a shrinkage of 5·0%.

At cone 06 the colour is a fine dark red and the body is strong and hard with a total shrinkage of [illegible]·6% and an absorption of 15·5%. This is but slightly changed at cone 03, indicating a burning range from cone 04 to cone 1. Deformation takes place with cone 6.

The only advantage clays of this vicinity may have over the clays at the south end of the lake is the immediate association with a fuel supply.

The nearest outlet to the Canadian Northern railway would be a siding about one and a half or two miles long.

CLAYS OF DIRT HILLS DISTRICT.

The only clayworking plant in Saskatchewan, using the white burning refractory clays, is located at Claybank on the north slope of the Dirt hills, some thirty miles south of Moosejaw.

Several extensive landslides south of Claybank and again in the vicinity of sec. 11, tp. 13, range 26, w. of 2nd. mer., have exposed considerable sections of the Tertiary clays, sands, and lignites.

As far back as 1873, Dr. Bell[1] of the Geological Survey described the white beds of this locality, but it was not until about 1909 that their true refractory value was known.

Claybank.

In 1912, Ries and Keele[2] made a detailed examination of the deposits near Claybank and in 1912 reported as follows:— (See Plate XII).

The clays which were examined occur in sec. 28, tp. 12, range 24, west of 2nd. mer. and form a series of knolls at the base of the hills. All the beds appear to dip westward, the knolls having a steep eastern face and a gentle western slope.

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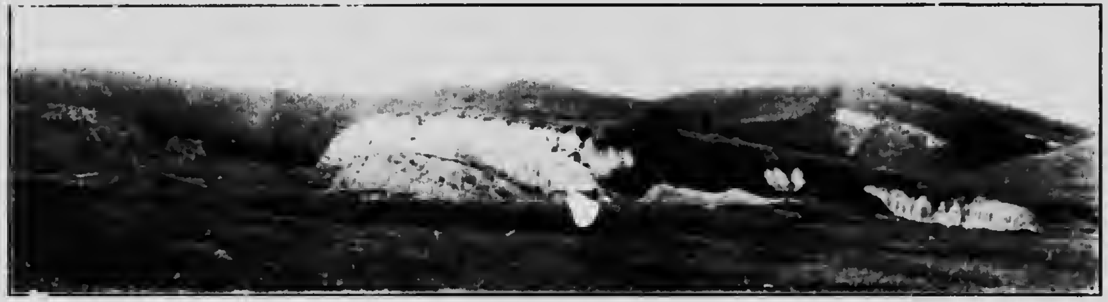
[1]Bell, Rep. of Progress, Geol. Surv. Can., 1873-74, p. 76.
[2]Ries and Keele, Memoir 24E., Geol. Surv. Can., 1912, pp. 84-92.

Plate XII.



Clay and shale outcrops, Dirt hills, Sask. View looking south from margin of hills. Deposit being worked by the Dominion Fire Brick and Clay Products Company.

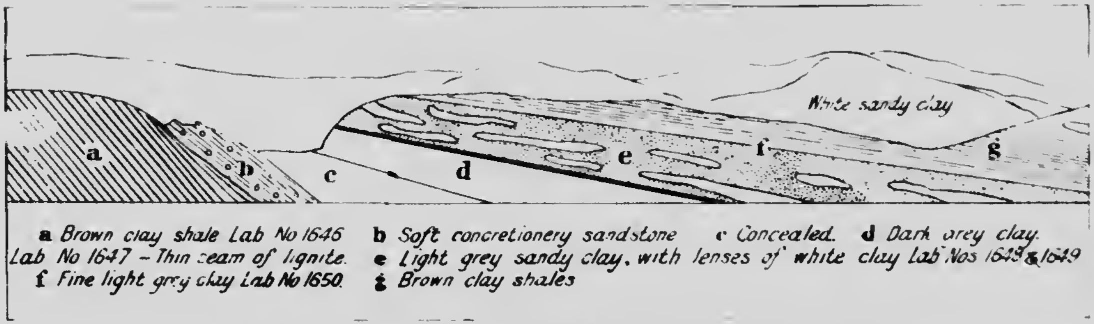


Fig. 1. Diagrammatic section of clay and shale outcrops shown on Plate XII.

[illegible]

The general topography of those hills in which the clay occurs is well shown in Plate XII.

They can be described as a series of white and greyish sandy clays, bluish and purplish clays, brown siliceous clay shale, and gypsiferous shales.

At the west side of the ridge is a spur or knoll containing a series of alternating red and brown siliceous shales. The individual beds of this series differ somewhat in their sandiness, and, if used, the entire series should be mixed together. (Sample 1646). A few scattered sandstone layers are present, but these are soft and could be easily crushed up.

1646. When ground and tempered with water this material formed a stiff plastic mass which was hard to work and checked badly in air-drying. As the clay was useless in the natural state a portion of the sample was preheated to a temperature of 500°C. Under this treatment the clay changed to a red colour, became granular in texture, but retained sufficient plasticity to be wet-moulded. It also stood wet-drying and the air shrinkage was 3·3%.

Cone	Fire shrinkage.	Absorption.	Colour.
010	1·7%	9·7	light red
03	9·3	5·5	red
1	13·3	vitrified	brown

This clay has too high a fire shrinkage, but it might be useful to mix with some of the more refractory clays of the locality in order to produce vitrified ware at lower temperatures or speckled effects in face brick.

Hill No. 2 shows heavy beds of grey and greyish-white sandy clay and brownish grey clay, the two sets being separated by a thin layer of lignite. The b[illegible] clay (No. 1647) forms a bed about 20 feet thick in the lower [illegible] section.

1647. [illegible] plastic clay, containing much fine grit, which worked up with 3[illegible] water. Small pieces dried slowly without cracking but large ones cracked badly in rapid drying. The average air shrinkage was 8·5% and the average tensile strength 334 pounds per square inch.

The wet-moulded bricks yielded the following results on burning:—

Cone.	Fire shrinkage.	Absorption.	Colour.
010	0·2%	16·38%	pale red
03	4·4	7·52	light red
1	5·4	4·28	brown
3	5·3	4·39	"

The air shrinkage is somewhat high, but in actual working it would be lower. The fire shrinkage at cone 1 is not excessive. The absorption at this cone is also low. The clay burned steel hard at cone 03, but if fired too rapidly may develop a black core at cone 1. It burned to a good hard body and stands cone 3. The clay gave a dry-press bricklet of fair colour and ring at cone 05, but if moulded by this method should probably be burned to cone 03.

The absorption at cone 05 was 18·62, and at cone 03 it was 10·93, with the bricklet steel hard.

Overlying the preceding is a grey and white sandy clay (1648), containing lenses of white clay (1649). Where the clay is exposed it would hardly pay to separate these lenses, but if they occur in greater quantity in other parts of the deposit it would be worth doing so. On this account a test was made of the run of the deposit, including the white clay, and also of the latter alone.

The run of bank (1648), although containing considerable sand, worked up with 27% of water to a mass of good plasticity, and one which caused no difficulty in moulding.

The average air shrinkage was 6·1% and a full sized brick stood fast drying.

The clay appears to contain a noticeable amount of soluble salts, which collected on the corners and edges of the brick in drying, and caused a slight enamel on those parts even at cone 03.

Wet-moulded bricklets yielded the following results:—

Cone.	Fire shrinkage.	Absorption.	Colour.
010	0·0%	18·58%	white
03	2·7	15·41	"
5	2·7	10·70	"
9	3·3	9·81	"
32	Fused	....	....

Small black iron specks began to appear at cone 1.

The clay has a low fire shrinkage, and the absorption above cone 010 is not excessive. It burned steel hard at cone 1.

This clay can be classed as a fireclay.

A dry-press bricklet burned to cone 1 was not steel hard with an absorption of 17·50 per cent.

Since the clay is rather loose in texture, it was put through a washing test and 45% of washed product (1648W) obtained. The latter showed an average air shrinkage of 8·5%. Burned to cone 5, its fire shrinkage was 9·7%, absorption 7·11%, and colour light creamy-white. It was also steel hard, but showed some small cracks. At cone 9, the fire shrinkage was 11·3%, absorption 3·7%, and colour greyish-white.

Since there is a large quantity of this material it might pay to wash it and use it in pottery bodies. Some difficulty would be encountered in getting sufficient water, but the springs on the neighbouring slopes could be drawn upon for this purpose.

The white clay (1649) forming lenses in 1648, although appearing smooth, nevertheless contains considerable fine grit, and an appreciable quantity of soluble salts, which come out on the edges as needle shaped crystals in drying.

It worked up with 30% of water to a mass of good plasticity, whose average air shrinkage was 7·7%.

On burning, the wet-moulded bricklets behaved as below:—

Cone.	Fire shrinkage.	Absorption.	Colour.
010	0·35%	16·74%	Creamy-white
03	3·7	10·34	"
1	5·3	7·67	"
5	6·6	4·67	"
9	6·6	2·60	"
31	Fused	....	....

The clay burned nearly steel hard at cone 010 and gave a pretty dense body at cone 5. Small black iron specks appeared at cone 1. This is a dense burning fireclay and it is unfortunate it does not occur in larger quantities.

The grey clay (1650) described here, overlies 1648. It does not appear in the steep southern escarpment of the hills but shows on the gentle north slope. Like 1648 it mixed up to a mass of good plasticity, whose average alr shrinkage was 7·8 per cent.

Wet-moulded bricklets were tested as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour.
010	1·0%	16·76%	Creamy-white
03	3·6	11·60	"
1	6·0	8·23	"
5	6·6	4·37	"
9	8·4	2·25	"
32	Fused	....	....

The clay burned nearly steel hard at cone 010 and thoroughly so at cone 03. Small black specks appeared at cone 010.

This clay resembles 1649 but has a slightly higher fire shrinkage. It is a good dense burning fireclay and well worth working.

Owing to the fact that 1646 cracked badly in drying it was decided to try a mixture of equal parts of 1646, 1647, and 1648. This (1651) when tempered with 32 per cent of water was very plastic and small test pieces dried without checking. The air shrinkage was 8 per cent.

The wet-moulded bricklets fired as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour.
010	1·0%	14·16%	light red
03	3·3	8·00	red
1	4·3	5·30	brown

The mixture burned to a steel hard body at cone 010, at which temperature it would probably make good common brick either by the soft-mud or stiff-mud process. At cone 1 the fire shrinkage is rather high and the body not burned quite dense enough for sewerpipe, but would probably become more vitrified at cone 2.

The mixture makes an excellent dry-press brick of good colour and steel hardness at cone 05, with an absorption of 13·75%.

Since the above report was made the Saskatchewan Clay Products Company (now the Dominion Fire Brick and Clay Products Company) have been operating a dry-press brick plant (see Plate XIII) at this location, and the results have borne out the above report. Until early in 1917 the chief product was a range of flashed face brick manufactured principally from the fireclays. An attempt was made to produce a red brick using a similar mixture to 1651, but the mixture did not work well in practice. The excessive shrinkage of the red-burning clay (1646) caused fire checking. However, there are possibilities in using less of 1646, or by calcining it and then using it in mixtures up to as high as 50 per cent.

There is a possibility of finding red-burning clays in the series of beds above the white clays where they occur in place near the top of the main hills. At present the upper slopes are well grassed, but, when a red-burning clay is needed, a little prospecting above the level of the white band might prove of value.

The reorganized company proposes the installation of a producer gas burning system and an expansion of the plant to manufacture firebrick and fireclay shapes. With this enlarged plant, the development of a greater range of face brick textures and colours should accompany the production of refractories.

At Dickenson and Hebron, North Dakota, similar clays are worked for firebrick and face brick. In the earlier exploiting of these deposits the dry-press process was the only method used for moulding the brick, but with the increasing demand for rough textured brick, stiff-mud machines were installed and operated with considerable success. This appears to be a logical development in the Canadian plant.

South of Claybank in section 24, tp. 12, range 24, west of the 2nd. mer., boring for lignite was in progress during the summer of 1911. An examination of the clay outcrops and borings at this locality was made by J. Keele at that time, a complete account of the results with tests being given in Memoir No. 25, of the Geological Survey. The white clays at this point are not so thick as those at Claybank, but heavier beds occur on section 11 of the same township.

PLATE XIII

Plant of the Dominion Fire Brick and Clay Products Company, Claybank, Sask. (Outcrop of white fireclays shown in the background.)

PLATE XIV

Sewerpipe plant of the Alberta Clay Products Company, Medicine Hat, Alberta.

A chemical analysis of a sample of the washed clay from section 24 is as follows:—

Silica	51·94
Alumina	33·62
Iron oxide	1·5
Lime	0·23
Magnesia	trace
Potash	0·82
Soda	0·22
Sulphur trioxide	none
Loss on ignition	11·44

This compares very favourably with analyses of whiteware clays from Woodbridge, N.J., and Salina, Pa.

Blue Hills.

Twelve miles due west of Claybank, on sec. 11, tp. 13, range 26, w. of 2nd. mer., the following bank of clays was measured, near the top of the east-facing escarpment of the Blue hills. Although this outcrop is some distance from a railway, the presence of the white refractory clays may make it of importance in the future.

Top, Gypsiferous yellow clays, thin lignite seam included	30 feet	
Purplish-grey clay	5 „	No. 485.
Alternate clay and lignite seams	4½ „	
Light grey clay containing some selenite	4 „	No. 486.
Greyish-white sandy clay	6 „	No. 487.
Greyish-white clay	3 „	
Carbonaceous brown clay	2 „	
Dark grey clayey sand	1 „	
Purplish-grey clay	6 „	No. 488.

The gypsiferous yellow clays and silts of the upper part of the section, when moulded into brick by the wet method, crack in air-drying. They are red-burning.

The purplish-grey clay, No. 485, in the five-foot bed below, although different in colour from the yellow beds above, acts very much the same. It is stiff and sticky and will not stand fast drying. In slow drying a heavy scum is apparent, and on burning the brick this scum hides the salmon-red colour of the body. This clay has no value considered alone, but might be mixed in small percentages with the sandy refractory clays below for making face brick.

486. This is a light grey clay which requires 24% of water to temper it to the stiff-mud condition. It has excellent working qualities and dries without difficulty to a shrinkage of 7·0%. Burned to cone 03 the colour is cream, the total shrinkage 8·0%, and the absorption 11·3%. Deformation takes place with cone 28.

This is a No. 3 grade refractory clay of an open-burning character up to at least cone 9. It has a value for face and firebrick.

487. Immediately below bed 486 there is a six-foot bed of greyish-white sandy clay in which a few streaks of iron stained material occur. It works up into a mass of fair plasticity, but decidedly gritty, with 23% of water. The drying of ware made from it can be carried on either slow or fast without fear of cracking, the air shrinkage being 6·0%. Soluble salts in small amount appears where evaporation is most intense.

Burned to cone 03 the colour is cream, the total shrinkage is 6·0, and the absorption 15·8%. At cone 9 the total shrinkage is 7·0% and the absorption 11·6%, indicating a rather open, burning body. Deformation takes place with cone 20.

This material is only semi-refractory, and would have a use as part of a mixture with the other clays of the section for making face brick.

The open-burning nature of both 486 and 485 would make them unsuitable for making vitrified ware, unless mixed with a low temperature (cone 1-3) vitrifying material.

488. The thickest bed in the lower part of the section consists of some six feet of a purplish-grey clay. A sample of this requires 23% of water to develop a rather stiff and sticky type of plasticity. Drying proceeds slowly without cracking to a shrinkage of 10·3%, but it is doubtful if the material will stand commercial fast drying. The shrinkage is excessive and a further defect in the form of a heavy scum becomes apparent in the burning.

Burned to cone 06 the colour of the body is a salmon-red but the surface is covered by the scum mentioned above. Deformation takes place with cone 6.

The uses to which this material could be put would depend on the working of the rest of the section for making dry-press brick.

CLAYS OF THE ESTEVAN-WEYBURN DISTRICT.

Brooking.

In a coulée near Brooking station on the C.N.R., Bengough branch, a 2-ft. seam of greyish-white plastic clay was sampled by Rose in 1913. It was completely hidden, in 1915, by the filling for a bridge, so its extent was not determined. When tempered with 21% of water this clay forms a very plastic mass of good working qualities. Its drying shrinkage is 5·0% and it will probably dry intact when made into full sized wares. This clay burns to a cream-coloured body at all temperatures up to cone 5, and the body remains open and porous, behaving so far like a fireclay. The body is vitrified and grey in colour at cone 10. Deformation takes place with cone 20, indicating a semi-refractory material suitable for high grade face brick, sewerpipe, and possibly stoneware.

The clays associated with it are stiff and sticky in their working qualities and defective in the drying process.

Yellow Grass.

Near Yellow Grass and Halbrite there are outliers of the Whitemud beds. That at Yellow Grass is not exposed at the surface but is covered by 20 to 30 feet of boulder clay on sec. 24. tp. 10, range 17, w. of 2nd. mer. That at Halbrite is exposed in a wide coulée tributary to the Souris valley, on sec. 30, tp. 6, range 12, w. of 2nd. mer.

565. The white clay at Yellow Grass was discovered in a well boring about 1907, and samples taken at depths of 50 feet were reported on by the Mines Branch. In 1916 a small sample was collected in the field, and a third sample was taken from a trial shipment made by the owners to an eastern refinery.

The clay is sandy but has good plastic properties, requiring only 20% of water to temper to the stiff-mud consistency. It dries without defect, either slow or fast, to an air shrinkage of 5·0%. It burns to an open porous body without much fire shrinkage at all temperatures up to at least cone 10.

Deformation takes place with cone 28, indicating a material of No. 3 refractory grade.

All three samples examined are of the sandy type, and it is probable that the plastic clays noted in the white band at other localities have here been cut away by glacial erosion.

Unless further prospecting shows this material to have less overburden than observed in 1916 its extraction will be costly. It would have the competition of the more refractory and easier worked clays found outcropping at the surface along the C.P.R. Weyburn-Stirling branch at Willows.

Halbrite.

556. Similar material to 565 of the Whitemud beds outcrops in a coulée about 2 miles west of Halbrite. It is underlain by a considerable thickness of the Estevan beds. The coulée sides are much disturbed by faults and slips, and the Whitemud material has been protected from erosion by being in a depression caused by the tilting of a fault block. In the vicinity the overburden is slight, and prospecting back from the coulée side may show up considerable good clay.

Burning tests on this clay show it to be in all respects similar to that tested from Yellow Grass. The air shrinkage is 5·0%, and when burned to cone 7, this is increased to 7·0%. Deformation takes place with cone 27, so that it is a No. 3 fireclay.

This material, as well as that at Yellow Grass, if the latter can be extracted profitably, should find a market in established brick plants, such as those at Estevan and Weyburn. It could be mixed with the red-burning clay in various proportions and a larger range of high grade face brick manufactured.

The Estevan beds at Halbrite contain too much colloidal matter to be considered for clayworking. The drying defects are very bad.

Weyburn.

At Weyburn a small brick plant was started in 1910 using a loamy surface clay of Pleistocene age. This clay is only six feet deep and is underlain by stratified gumbo clay containing numerous concretions and some pebbles. The top clay burns to a good red colour, but the body is not strong and is easily over fired. The lower clay is too badly contaminated by calcareous concretions to be of much value unless ground very fine. As was mentioned above, this plant might be turned over to use the refractory clay from Halbrite or Yellow Grass in a mixture with the red-burning surface clay.

Estevan.

The vicinity of Estevan is rich in resources of lignite coal and the common grades of clay. Hence it would appear to be the logical place for the economic production of structural materials such as brick and fire proofing.

The Estevan Coal and Brick Company has a well established plant at Estevan, manufacturing buff stiff-mud (side cut) brick, and red dry-press face brick, from clays associated with the coal.

Plate XV illustrates the general location of the plant, and Plate XVI the clay pit, with the surface outcrop of the coal seam showing.

The following is the section of clay and lignite mined:—

Top, Glacial drift	very thin.		
Yellow calcareous and sandy clay	10	feet	No. 1645.
Greyish-yellow clay more plastic than that above	4	„	No. 566.
Lignite	8	„	
Parting clay	2	„	
Lignite	1	„	
Blue clay with sandy bands, particularly towards the bottom	30	„	

Ries[1] describes the upper yellowish clays as glacial, but they belong to the upper part of the Fort Union formation and may be referred to the Ravenscrag division. The top clay contains hardened sandy layers, very much ripple marked.

[1]Ries, Memoir 24E., G.S.C., 1912, p. 79.

PLATE XV

Plant of the Estevan Coal and Brick Company, Estevan, Sask.

PLATE XVI

Clay pit of the Estevan Coal and Brick Company, showing top bed of buff burning clay; intermediate bed of lignite coal; and lower bed of red burning clay.

Towards Roche Percée the yellow calcareous beds increase in thickness and occupy the whole of the valley side. These clays are of great value to the common brick industry because they are easily worked and will dry fast in an artificial dryer without checking.

1645. This is a yellow calcareous clay which requires 21% of water to temper to the stiff-mud condition. It can be dried slow, or fast (20 hours), without defects to a shrinkage of 5·0%. The best body is produced in a range from cone 03 to 1. Deformation takes place with cone 3. It is used for wire-cut brick and has possibilities for hollow block.

566. The yellowish-grey clay under 1645 and immediately above the coal seam is of excellent plasticity and working qualities. It burns to a pink colour when made up stiff-mud, and the burning range is from cone 05 to cone 02.

Made up in the dry-press way the burnt colour is a speckled buff, and the burning range is from cone 04 to cone 1. It deforms at cone 3.

This clay has a value as a dry-press face brick material, and as little as possible should be used in with the upper calcareous clay for common brick.

504. Near the bridge south of Estevan there is a section of some ten feet of silty clay in the river bank. This material is very short in its working qualities and requires careful handling in drying, when moulded in the soft-mud way. It burns to a porous weak body up to cone 1, beyond which it shrinks rapidly. It has doubtful value for making clay ware.

557. A grey calcareous clay, above the coal, was sampled in Anderson's coal mine in Long Creek valley. It requires 26% of water to temper to the stiff-mud condition. It moulds rather stiffly, and would require more power to work it than the other calcareous clays tested in the district. The air shrinkage of 6·3% is well within practical limits, and fast drying can be carried on without trouble.

Burned in a range from cone 010 to cone 1 the body is salmon-pink in colour and has good strength. The total shrinkage increases regularly from 7·0% at cone 010 to 10·6% at cone 1. In this range the absorption remains around 24%. Deformation takes place rapidly at cone 3.

This material would make a good common wire-cut brick or hollow blocks.

Shand.

Six miles southeast of Estevan, at Shand station, the Saskatchewan Coal, Brick and Power Company is operating a lignite mine and manufacturing stiff-mud (side cut) common brick (Plate XVII). The coal is mined by underground methods at a depth of seventy feet. The clay is taken from a fifteen-foot open-cut to the west of the plant. In the pit the following section was measured:—

Top, Thin glacial covering....................		
Yellow clay..............................	5′-0″	
Thin lignite seam........................	0′-1″	
Grey clay and sand......................	4′-0″	No. 560A.
Thin lignite seam........................	0′-1″	
Grey clay..............................	2′-00″	No. 560B.
Thin lignite seam........................	0′-2″	
Grey clay..............................	4′-0″	No. 560C.

The run of bank is manufactured into an excellent grade of common stiff-mud brick, pink to cream in colour. In the yard a number of the brick were observed to contain stiff lumps of red-burning clay, and the following tests on the lower three beds indicate that bed No. 560B is the only one free of red-burning clay bands.

560A. This is grey calcareous clay which develops a silty type of plasticity with 21% of water. The drying properties are excellent and the shrinkage only 6·0%. It burns to a good hard body, pink to cream in colour, in a range from cones 010 to 03. It is overburned at cone 1 and the body shows numerous lumps of clay burned red. It deforms completely with cone 3.

560B. This is a greyish clay of excellent plasticity when tempered with 23% of water. It dries without defects to a shrinkage of 6·0%.

Burned to cone 05 the body shows a swelling typical of calcareous clays, the total shrinkage being 5·0%. It has a burning range from cones 010 to 03 in which a good common brick can be made. At the lower temperatures the colour is pink but this changes to cream at cone 05. The deformation temperature is cone 4.

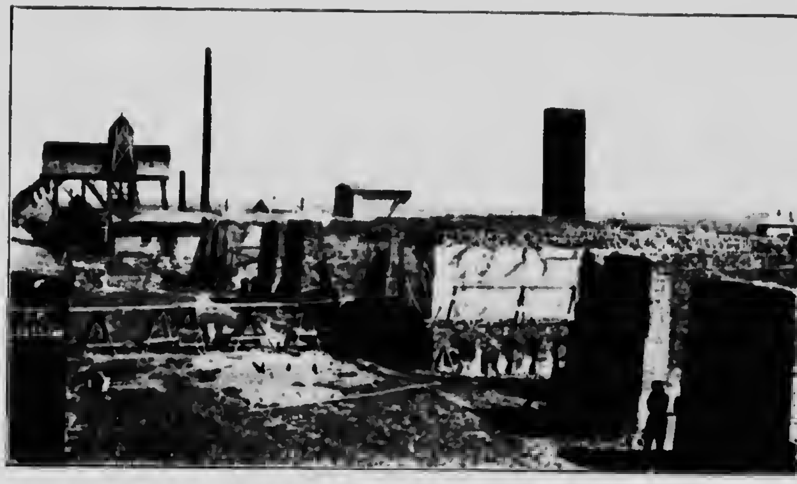
560C. The lower grey clay requires 20% of water to temper it to the stiff-mud condition. It dries without defect to a shrinkage of 7·0%.

Burned to cone 05 the body is light pink in colour, the total shrinkage is 8·0% and the absorption 13·4%. This clay has a burning range for good brick of cones 010 to 03. Above this temperature the shrinkage increases rapidly and lumps of dark red clay show up against the buff groundmass.

508. Immediately above the coal at a depth of about seventy feet there is a bed of calcareous silty clay very similar to those sampled in the clay pit. It works up into a mass of excellent plasticity with 23% of water and dries without defect to a shrinkage of 5·0%.

Burned to cone 05 the total shrinkage is 6·3%, the body is hard and the colour a good cream. The absorption is rather high at 27·5%. At the higher temperature of cone 1 the cream colour turns to a greenish-yellow, the total shrinkage is 6·6% and the absorption 25·5%. Deformation takes place with cone 5.

PLATE XVII



Brick plant and coal tipple of the Saskatchewan Coal, Brick, and Power Company, Shand, Sask.

PLATE XVIII

Plant of the Weyburn Brick Company, Weyburn, Sask.

This is a good common brick clay and can be worked like the clays already being used for wire-cut brick.

Near Mileage 141 + 300 on the C.P.R., southeast of Estevan, the greyish-yellow calcareous clays outcrop at the surface. A sample collected to the west of the track proved to be similar in its working qualities to the clays of the same position at Estevan and Shand.

On the west side of the Souris valley and for some distance up Long creek these same yellow calcareous clays are found outcropping in the valley sides. Their resemblance to the Ravenscrag beds is suggestive, and going south, down the main valley towards Roche Percée, this resemblance is seen to be more definite.

Roche Percée.

The red-burning Estevan beds dip beneath the river at Roche Percée and the whole height of the valley side consists of calcareous clays, silts, and sands.

At the junction of a tributary coulée northwest of the school house the following partial section was measured:—

Top, Burnt clay—ash and glacial material......	6′-0″	
Yellow silty clay with concretions.........	10′-0″	No. 511.
Lignite...	0′-8″	
Rusty grey clay including thin lignite bed.	9′-0″	No. 510.
Lignite..............................	2′-0″	
Grey clay and silt......................	8′-0″	No. 509.
Clayey grey sand......................	6′-0″	
Lignitic clay with concretions...........	3′-0″	
Greyish sands and silts..................	20′-0″	

509. This is a grey silty, calcareous clay, and, although only 22% of water is required to mould it, brick made of it require to be carefully dried to avoid checking. The air shrinkage is 8·0%. It burns to a good strong buff-coloured body at cone 06, and continues so to cone 03. If mixed with some of the other clays of the section it would make a good common building brick. Deformation takes place with cone 3.

510. Sample of a yellowish-grey calcareous clay which requires 23% of water to temper to the stiff-mud condition. It dries slow or fast without sign of defect, the shrinkage being 6·0%.

Burned to cone 05 the colour of the body is a pinky-cream, the total shrinkage is 6·0% and the absorption 21·7%. The body remains good up to cone 02, beyond which the shrinkage increases rapidly and the colour becomes greenish-yellow. Deformation takes place with cone 3.

The principal use to which this material might be put would be for common brick and possibly hollow block by the stiff-mud process.

511. The thickest bed in the upper part of the section consists of yellow silty clay containing a few concretionary lumps. These were suspected of being high in lime but the burnt test pieces show no sign of lime particles. This clay is more silty than those in the lower part of the section and would work better mixed with them. The air shrinkage is 4·6% on stiff-mud test pieces and the drying can be accomplished without trouble either slow or fast. It burns to a very porous pink to cream-coloured body of fair strength and hardness in a range from cones 010 to 03. In this range the fire shrinkage remains at zero. It will make common, buff or cream-coloured brick.

512. In the valley bottom of the Souris, near the school house at Roche Percée, the river cuts into a bank, showing eight feet of silty clay underlain by sand. This clay requires 21% of water to temper it to the soft-mud condition. It dries without cracking to a shrinkage of 7·0%.

Burned in a range from cone 010 to cone 1 the colour changes from light red to dark red, and the fire shrinkage remains practically at zero. A small amount of scum is evident, but this could be cured by the addition of a small amount of barium salt.

This is one of the few good red-burning common brick clays in the district. It would work best by the soft-mud process.

Pinto.

The Pinto Coal and Brick Company operated a mine in the upper lignite bed in 1910, and the shales overlying and underlying the coal seam were accessible for examination at that time. A very complete report with tests on these shales is given in Memoir 24 of the Geological Survey.

Bienfait.

East of the Souris valley the glacial boulder clay thickens and the underlying formations are not well exposed to view. At Bienfait several companies are mining coal at a depth of 80 feet, and, in sink-holes on the properties, the boulder clay is seen to have a thickness of 15 feet. It is underlain by the yellow and grey calcareous beds referred to the Ravenscrag division. The coal seam is overlain by a calcareous silty clay similar to that noted over the coal at Estevan, Shand, and Roche Percée.

In general it may be stated that the clays above the main coal seam can all be used for making common brick and face brick, by both the stiff-mud and dry-press methods. Certain of the beds will make hollow ware. None of the clays have any refractory value.

East from Bienfait the country has a rolling glacial morainal topography and in the vicinity of Oxbow the drift has a thickness of several hundred feet. No good clay was found in the extreme southeastern part of the district, but further prospecting in the flood plain of the Souris river, where it is crossed by the G.T.R. north of Elcott, and in the flood plain of Antler creek between Carnduff and Carivale, may show up small bodies of material suitable for making common brick.

Arcola.

South of Moose mountain (a large glacial moraine) there are numerous small basin-shaped areas, the sites of extinct lakes or ponds, in which good buff-burning common brick clays are to be found. At Arcola a stiff-mud brick plant has been in operation for a number of years using the clay of one of these basins located on the outskirts of the town. The clay is a yellowish-grey calcareous material containing crystals of selenite. It is worked to a depth of six feet. In places it is quite stiff and plastic, in others it is sandy and short.

Care is needed in digging the clay to assure a good mixture. It works well in a stiff-mud machine and dries slowly without defect in open hacks, a reasonable amount of care being taken to protect the ware from excessive wind and sun.

Burning is carried on in scove kilns to a temperature of cone 05 for good hard buff brick. Ware burned to cone 010 is pink in colour and shows white particles of burnt gypsum. On standing in the air these particles take up moisture and spall the brick. Hence it is desirable to carry the burning temperature to cone 05. It does not deform until cone 3 is reached, indicating a safe-burning range for good brick of cones 05 to 02. At cone 05 the total shrinkage is 7·6% and the absorption 20·2%.

Carlyle.

East of Arcola, to Manor, there do not appear to be any good clays, the surface covering being largely stony boulder clay. At Carlyle an attempt was made, a number of years ago, to make soft-mud brick from surface clay to the north of the town. A small scove kiln was set but never burned. An examination of the brick showed the presence of numerous limestone pebbles.

Stoughton.

West of Arcola, towards Stoughton, there are numerous depressions containing clay similar to that used at Arcola. Along the road between secs. 20 and 29, tp. 8, range 8, w. of 2nd. mer., near Stoughton, a small sample (No. 561) was collected from one of these clay basins. It represents a depth of 3 feet.

561. This is a yellow surface clay which requires only 22% water to develop an excellent grade of plasticity. It dries without defects to a shrinkage of 8·3%.

Burned to cone 010 the colour is pink, the total shrinkage 8·3% and the absorption 17·7%. At this temperature the body is fairly hard and no gypsum is evident. The body is a good buff colour at cone 05 but best at cone 03. At this latter temperature the total shrinkage is 9·0% and the absorption 15·7%. At cone 1 the body is on the verge of being over burned and deformation takes place with cone 3.

This material will make a good buff-coloured common brick burned in a range from cones 010 to 02.

CLAYS OF THE NORTHEASTERN PART OF THE AREA.

Regina.

The immediate vicinity of the capital of the Province is poor in workable clay resources. The city is built on the site of an extinct glacial lake, but the clay deposited in the lake bottom was derived largely from the erosion of the stiff and sticky Pierre shale. Hence wet-moulded bricks, made from this material crack badly in air-drying, and when made up dry-press the clay has excessive shrinkage, with a burnt body of low strength and high porosity. The burnt colour is red but obscured to some extent by white scum.

A section observed in the excavation of a trunk sewer in 1911 contained the following material:—

Top, Dark coloured loamy clay	4′-0″
Stiff dark clay, jointed	15′-0″
Yellow silty clay	2′-6″
Stiff dark clay, jointed	10′.

The jointed clay forms the greater part of the section, and unless it could be preheated with success commercially it would have no value as a clay working material.

The yellow silty clay (Sample No. 1809) is a workable material, but unless found in quantity at the surface somewhere it has no commercial value. A careful search of the stream valleys in the vicinity of the city did not reveal any quantity of the yellow clay, but a flood plain deposit of similar material was found in the valley of Waskana creek one mile north of Condie. The stream bank shows some six feet of good clay overlying a bed of stony clay.

521. Laboratory tests on a sample of the bank show the material to be calcareous and to have fair working and drying qualities. The drying would be improved by the addition of 20% of sand. The air shrinkage is 6·3%.

Burned to cone 010 the colour of the body is pink, the total shrinkage 7·0% and the absorption 20·4%. At higher temperatures up to cone 03 the colour changes to buff, the body is hard and the absorption decreases to 17·3%. At cone 1 the body is hard burnt and deformation takes place with cone 5. Cone 03 is the best burning temperature.

This material promises well as a common brick clay, but more extensive drying tests would be necessary to give it definite value.

564. A calcareous clay was found in a flood plain in the valley of Boggy creek along the north side of sec. 11, tp. 18, range 9, w. of 2nd. mer. It cracks badly in drying and requires as much as 50% of sand to overcome this defect. With this large amount of sand in the body it is possible to make soft-mud brick of the material requiring to be burned as high as cones 05 to 1 to produce brick of good strength. Plenty of sand is available in the large sand pit one mile to the east of the clay bed.

Pilot Butte.

East of Regina towards Pilot Butte the Canadian Pacific railway line passes from the old glacial lake bottom onto a sandy glacial outwash area of which Pilot Butte appears to be the centre. Two brick plants are in operation at this station, one using the sand of the outwash for sand-lime brick, and the other, the silty clay found in small basins within the sand. These basins are very small and irregular, and much trouble is experienced in making brick from the clay because of the presence of lenses of stiff gumbo clay similar to that of the plain to the west.

East and northeast of Regina, to the Manitoba boundary, the country changes from the level treeless plain to rolling wooded topography. On the surface numerous extinct glacial lake basins are to be found, in, and between the main moraine systems.

The glacial material, boulder clay, covering the Cretaceous rocks, is of considerable thickness and bed rock exposures are few. From Lost Mountain lake to the vicinity of Tantallon, in the Qu'Appelle valley, the full depth of the valley sides (200 to 300 feet) consists of glacial drift.

Wolseley.

Along the main line of the Canadian Pacific railway, east of Wolseley to Whitewood, there are many of these clay basins containing workable deposits of buff-burning clays. At Wolseley a soft-mud brick plant was in operation a number of years ago using a yellow silty clay taken from a basin to the south of the railway. Many of the stores in the town were built of brick made in this plant about 1898, and their present excellent condition attest the quality of the product.

Summerberry.

562. East of Summerberry station there is a wide flat underlain by stratified clay. A sample collected in a 3-foot ditch on sec. 8, tp. 17, range 8, w. of 2nd. mer., works up to a mass of good plasticity with 28% of water. It would work better with about 20% of sand. The drying qualities are bad, full sized brick cracking badly in slow drying. The air shrinkage is 8·0%.

Burned to cone 010 the body is light red, but the colour is partly obscured by white scum. At this temperature the total shrinkage is 7·0% and the absorption 12%. At higher temperatures up to cone 03, the shrinkage does not materially increase but the effect of the scum is more pronounced.

The material represented by the sample would be difficult to work because of the sticky plastic nature, scumming and cracking defects in the drying process. About a mile farther east, near the margin of the flat, a more sandy clay might be found, but the scumming defect would probably still be present.

Broadview.

At Broadview, the Broadview Brick Company operates a soft-mud brick plant using a buff-burning surface clay found in a flat north of the railway. See Plate XIX. The product is a good grade of common brick and has been largely used in the district for constructing stores and houses. An attempt was made to use the clay in a stiff-mud machine, but lamination intensified the brittleness of the material in the burned brick made by this process. This was the only idle plant in southern Saskatchewan during 1916, due largely to internal business difficulties. There is plenty of good soft-mud brick clay in the vicinity.

Qu'Appelle Valley.

Tantallon.

The most important clayworking material discovered in the north-eastern part of the area is the Odanah shale horizon of the Pierre formation which outcrops in large exposures a hundred feet thick in the Qu'Appelle valley near Tantallon.

The Canadian Pacific railway, Brandon-Saskatoon branch, descends from the south through Cut Arm creek coulée, follows the main valley for several miles and ascends another large coulée to the general level of the country north of the valley. The best exposures of the shale occur along the railway southeast from Tantallon, and particularly good sections are accessible near the bridge over Bear creek. See Plate XX.

The upper sixty feet in this section consists of hard grey, thinly bedded shale having iron oxide stain along the fracture and bedding planes. Below this there is a very heavy talus of the shale only in small part weathered to clay, the greater proportion remaining in hard splintery fragments.

515. This is a hard grey shale slightly darker than the underlying part of the section. When ground to 16 mesh and tempered with water to the stiff-mud consistency it has good working qualities. A large sample was put through a stiff-mud machine and found to work very smoothly with a small amount of lubrication.

The drying properties of solid brick are fair, care being necessary to avoid unequal drying. Trouble is experienced in making hollow brick or block because of checking due to strains set up in the die. The material is therefore regarded as tender in its drying qualities for this class of ware.

PLATE XIX

Common brick plant of the Broadview Brick Company, Broadview, Sask.

PLATE XX

Outcrop of Odanah shale along the Canadian Pacific railway, between Rocanville and Tantallon, in the Qu'Appelle valley, Sask.

Burned up to cone 05 the colour is a beautiful red, the total shrinkage 9·7% and the absorption 24·6%. At cone 1 the total shrinkage is 11·0% and at cone 5, 15·3%. At the latter temperature the burnt colour is a rich dark red. Deformation takes place with cone 15.

516. The lower thirty feet of the section consists of thinly bedded light grey shale similar to that above. A few hard concretionary masses were noted towards the base. This shale, when ground to 16 mesh, acts much like 515 except that the air shrinkage of 5·0% is less. The working and burning properties are in all respects similar to 515.

A mixture of these two samples works very well in a stiff-mud machine with lubrication in making either brick or drain tile. Drying full sized brick requires some care, the moist air system being the most efficient. At cone 06 the total shrinkage is 7·5% and this increases to 8·3% at cone 03. In a range from cone 06 to cone 6 the colour changes from light red to a rich dark red. Flashing in the burning results in beautiful red and burnt orange tones. Deformation takes place with cone 15.

A dry-press brick burned to cone 03 gave a total shrinkage of 6·2%. Brick made by this process requires to be burned to cone 1 to get a strong body.

The mixture takes an excellent salt glaze at cone 7, but the body is not vitrified. It is not a good sewerpipe material but it will make a high grade face brick, either alone or mixed with the underlying beds represented by No. 1810.

No. 1810. The underlying Millwood beds are not exposed in the section described above, but a considerable thickness is to be seen in the road cuttings up the valley side south of Tantallon. The beds sampled at this point are dark brown to grey plastic shales. The material of which they are composed absorbs a large amount of water in developing maximum plasticity. Stiff-mud brick cracked very badly in air-drying. The burnt colour is a good red, partly obscured by scum. When burned to cone 05 the absorption is 1·3% and vitrification is complete at cone 1.

This clay might be of use mixed with the hard shale above for making dry-press brick. The vitrifying qualities at cone 1 would produce a strong brick from such a mixture.

The valley bottom contains flood plain clays that are inclined to be tender in their drying qualities, but prospecting near the valley sides may show up good workable material.

The red-burning and semi-refractory grey shale of the upper part of the valley sides is, therefore, the most important clay working material in the Tantallon district. It will make dry-press and stiff-mud brick of excellent quality, at least a pound lighter in weight than the average shale brick. Further testing will be necessary to definitely establish its value for hollow brick or block. The tender nature of the material indicates that the strains set up in the dies will cause cracking in air-drying, except under most favourable conditions. So much depends on the structure of the die for this class of ware that extensive testing is necessary.

Saltcoats.

North of the Qu'Appelle valley to Saltcoats, the country has a rolling morainal topography and is well wooded. About three miles southwest of Saltcoats there are wide flat treeless areas underlain by stratified silty clay. This material is yellowish in colour and very calcareous. It would be suitable for making buff or cream common brick by the soft-mud process.

Melville.

Farther west to Melville the rolling morainal topography comes in again and the town of Melville is built on a gravel outwash plain. This continues to about one mile east of Duff, where extinct lake basins or flats are found. These treeless flats are in striking contrast with the well wooded morainal areas.

In a road cutting along the north side of sec. 5, tp. 22, range 8, w. of 2nd. mer., and about 400 feet south of the railway track, some 4 feet of stratified clay, silt, and sand were found. This material is calcareous and burns to a buff or cream colour. It would be suitable for making common brick by the soft-mud process.

Balcarres.

Two or three miles south of Balcarres stratified clay was found in road-cutting, but the material is similar to that deposited in the larger glacial lake basins such as that at Regina. It is very stiff and sticky in its working qualities and cracks badly in air-drying.

519. More promising material occurs in smaller glacial lake basins in the glacial outwash area to the northwest of Balcarres. The silty calcareous clay from one of these basins along the railway half way between Balcarres and Patrick has been used for making soft-mud brick. The small plant on the property is in ruins at present.

A sample collected in a four-foot pit near the railway south of the brick yard was made up into soft-mud brick and found to have an air shrinkage of 4·0%. When burned to cone 03 the colour is buff and the total shrinkage 3·0%. The brick is hard but rather porous, with an absorption of 24·5%. Most of the brick in the abandoned scove kilns are salmon-pink in colour indicating a burning temperature of about cone 07. Better brick could have been made by burning to the higher temperature of cone 03.

In the Qu'Appelle valley, at the east end of the Qu'Appelle lakes a small soft-mud brick plant was in operation about 1900. Bricks were moulded by hand and burned in small scove kilns. The clay used was the top foot or two of the flood plain of the river south of the course of the present stream. The product was a fair grade of salmon to buff-coloured common brick.

Lebret.

518. At Lebret a stream tributary to the Qu'Appelle has built up an alluvial fan into the main valley, near the railway on sec. 1, tp. 20, range 14, w. of 2nd. mer. A cut bank shows some six feet of clay. This material requires only 21% of water to develop a silty type of plasticity. It has an air shrinkage of 6·6%, which is not excessive, but it cracks in drying. This defect could be overcome in making soft-mud brick by the addition of 25% of sand. Without sand it burns to a pink to buff body in a range from cone 010 to cone 1. The total shrinkage after burning is practically the same as the air shrinkage and the absorption remains at about 17·5%. The sample collected was too small to try mixtures with sand, but the material will probably require 25% to make common soft-mud brick.

Regina Beach.

Dark grey to brown shales of the lower part of the Pierre outcrop in the valley of Lost Mountain lake near Regina Beach. Samples of this material tested by Keele in 1912 were found to be defective both in drying and burning. A further examination of this material in 1916 confirmed the above.

Lumsden.

In the main Qu'Appelle valley at Lumsden the valley bottom silt could be used for making a fair grade of common soft-mud brick. This material burns to a salmon-pink colour at cone 07.

CLAYS OF THE NORTHWESTERN PART OF THE AREA.

Moosejaw.

An examination of the vicinity of Moosejaw failed to reveal material suitable for clayworking. An attempt has been made to work the boulder clay south of the town for soft-mud brick but considerable trouble was experienced with small limestone pebbles.

Three miles east of the town railway cuttings show nine or ten feet of stoneless clay, but this material is the typical gumbo of the district and cannot be dried successfully. When made up dry-pressed it burns to a body of low strength and high porosity at temperatures commercial for the material.

Mortlach.

Seven miles south of Mortlach the Fort Union beds outcrop in the north-facing escarpment of the Coteau. In the east bank of a coulée on sec. 17, tp. 16, range 1, w. of 3rd. mer., the following section was observed:—

Boulder clay	3 feet
Brown sticky clay	25 "
Lignite	1 "
Greyish-white plastic clay	9 "
Yellow sticky clay	? "

In the west bank of the coulée the greyish-white clay is nearer the surface, but it is thinner than in the east bank. Tests made by Keele[1] on a sample of this clay showed it to have the very high air shrinkage of 10·0%. It burns to a buff-coloured body in the temperature range of cones 03 to 5. It vitrifies at cone 10 and deforms at cone 20. It resembles a stoneware clay but it could not be used alone for this purpose because of the excessive shrinkage. It could be mixed with the other clays of the section for making dry-press face brick. It would also find a use in a sewer-pipe mixture.

So much of the country in the vicinity is covered by a mantle of boulder clay that it is impossible to form an estimate of the good clay available. Drilling in the areas along the railway west of Parkbeg might bring to light clays that could be mined for shipment to the sewerpipe works at Medicine Hat.

Herbert.

Rush lake occupies a depression between two morainic ridges, and its old shore line indicates at least twenty feet more water than that in the basin at present. A small creek enters the basin from the east and has built up a delta deposit of sand, gravel, and clay.

550. A sample of this clay was collected on sec. 3, tp. 17, range 10, w. of 3rd. mer. Soft-mud brick made of this material cracked in air-drying, but not badly. The air shrinkage is 8·6%. When burned to cone 010 the body is a dull salmon colour, the total shrinkage 8·6% and absorption 12·7%. The addition of sand to the amount of 20 to 25% would cure the drying defect, and a fair grade of soft-mud brick for backing purposes could be made.

Ardkenneth Post Office.

North of the South Saskatchewan river, near Ardkenneth post office, the Fort Union beds outcrop in the northeast facing hills of the Coteau.

[1]Keele. Memoir 66, G.S.C., 1915, pp. 24-25.

On section 17, tp. 21, range 10, w. of 3rd. mer., the following section was observed:—

Glacial boulder clay	24 feet	
Yellow clays	50 „	No. 552.
Black lignitic clay	1 „	
Greyish-white sandy clay	20 „	No. 551.
Yellowish-grey clays	?	

551. This is a sandy greyish-white clay which works up into a mass of fair plasticity with 20% of water. It dries without defect to a shrinkage of 6·0%.

When burned in a range from cone 03 to cone 9 it expands rather than shrinks, the burnt colour is a dirty cream, and the absorption remains around 13·0%. Deformation takes place with cone 26. This is a very open burning semi-refractory clay and it could be used alone for making a low grade of refractory or with other clays for dry-press face brick.

552. A sample of the yellow calcareous beds overlying the "white mud," requires 19% of water to develop a rather stiff type of plasticity. In air-drying the material cracks very badly and hence could not be used alone by either the soft-mud or stiff-mud process. The air shrinkage is 8·6% and when burned to cone 05 the shrinkage increases to 10·3%. The burnt colour is a fine red.

An excellent range of dry-pressed, flashed, face brick could be made by mixing 551 and 552 in various proportions.

The proximity of this section of clays to the Saskatchewan river suggests the possibility of transporting the material in scows down stream to Saskatoon to be manufactured into brick at that industrial centre.

Lucky Lake.

Four miles north of Lucky Lake post office, on the N.E. ¼, sec. 1, tp. 24, range 9, w. of 3rd. mer., a cut bank in a coulée shows a peculiar mixture of bright coloured clays and glacial drift. Masses of yellow, red, black, and white clays appear to have been transported by glacial ice and dumped at this point along with the common boulder clay.

Settlers of the vicinity have gathered the red ochreous clay for painting barns.

However, the material is not in place, and prospecting in the district failed to locate the source. In this locality the glacial ice movement was from a northeasterly direction, and the source of the clay may have been near or far.

Lancer District.

Along the Empress branch of the Canadian Pacific railway, from a point about two miles west of Shackleton, to Lemsford, the numerous railway cuttings show clay silt interstratified with very thin bands of stiff plastic clay. One mile west of Lancer a cut shows some ten feet of this sort of material, and at a depth of eight feet there is a band containing shells. This section is very conveniently located in regard to the railway and the town. (See Plate XXI).

547. A sample representative of the above described section requires 26% of water to mould it by the stiff-mud process. Full size brick dry without cracking in open air-drying. On test pieces the air shrinkage amounts to 8·0%.

Burned to cone 010 the total shrinkage is 7·3%, the colour is a good brick red, the body is fairly hard, and the absorption is 18·0%. At cone 03 the total shrinkage is 8·6%, the colour is a good dark red, the body is of excellent hardness, and the absorption is 15·0%. A small amount of scum is present but it could be cured by the addition of half a per cent of barium salt to the clay in the pug mill.

546. On sec. 36, tp. 21, range 23, w. of 3rd. mer., a railway cutting shows ten feet of stratified yellow clay-silt A sample representative of the bank requires 25% of water to develop a fair degree of plasticity for moulding in the stiff-mud condition. The drying shrinkage of 6·0% is well within commercial limits.

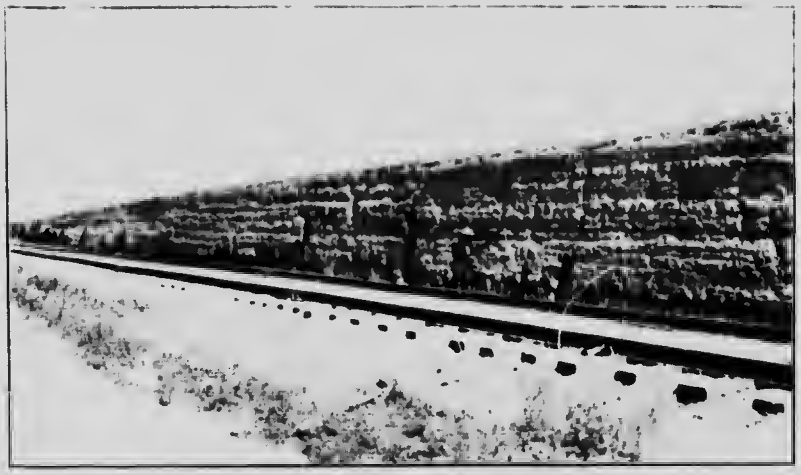
When burned to cone 010 the material shows no fire shrinkage, the body is of a dark salmon colour, and of good strength, the absorption being 20·3%. At cone 1 the body is dark red in colour and the total shrinkage has increased to 8·0%. The body would be overfired at cone 2 and deformation takes place rapidly with cone 3.

The material is suitable for making a good grade of either soft-mud or stiff-mud brick burned at temperatures ranging from cone 010 to cone 03. A minor amount of scum is apparent but less than a half of a per cent of barium salt would cure this defect.

548. Five miles east of Lancer, near Mileage 53 on the railway, a cut shows some twelve feet of stratified silt separated by thin bands of greasy clay. A part of the bank near the centre of the cut measured as follows:—

Top, Yellow silty clay	6·5	inches.
Greasy clay	0·5	"
Silty clay	3·0	"
Greasy clay	0·5	"
Silty clay	3·0	"
Greasy clay	0·5	"
Silty clay	7·5	"
Greasy clay	0·5	"
Silty clay	8·0	"
Greasy clay	0·5	"
Silty clay	6·5	"
Greasy clay	0·5	"
Silty clay, etc	10·0	"

PLATE XXI



Red burning glacial lake clays, near Lancer, Sask.

A representative sample of the bank requires 27% of water to work it in the stiff-mud condition. The working qualities are excellent and the drying of full sized brick can be carried on without defect, the air shrinkage being 8·0%.

Burned to cone 010 the total shrinkage is 8·0%, the body is hard and of a good red colour, and the absorption is 19·7%. At cone 1 the total shrinkage is 9·3%, the body is steel hard and of a dark red or brown colour, and the absorption is 15·0. Deformation takes place with cone 4.

This material will make a good red brick if worked by either the soft-mud or stiff-mud process and burned in a range of cone 010 to 03.

The usual scumming defect is present but less than half of a per cent of barium salt will cure it.

These clays of the Lancer district are an important clayworking resource of the country northwest of Swift Current. They will make a good grade of red building brick and will probably work well enough to make hollow building blocks and drain tile.

Estuary.

Near the bridge over the Red Deer river, west of Estuary, there is a considerable flat in the valley bottom underlain by silty clay. Also in a prominent butte known as the "Bull's Forehead" facing the river a considerable thickness of clay silt is to be seen. A section measured on the part of this butte resulted as follows:—

Top, Very fine sand or silt	60 feet	No. 545.
Sandy clay		
Silt and clay		
Plastic clay		
Boulder clay	30	"
Stratified sand with some clay	10	"
Boulder clay partly oxidized	10	"
River level.		

545. A sample of the sixty-foot section of clay, or clay and silt, requires 26% of water to work it in the stiff-mud condition.

It requires extreme care in the drying process to avoid cracking; and a further defect is present in the form of a very bad scum. It would not be advisable to work this material for brick because of these defects, and the fact that so much good clay is available along the railway east and west of Lancer.

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CANADA

DEPARTMENT OF MINES

MINES BRANCH

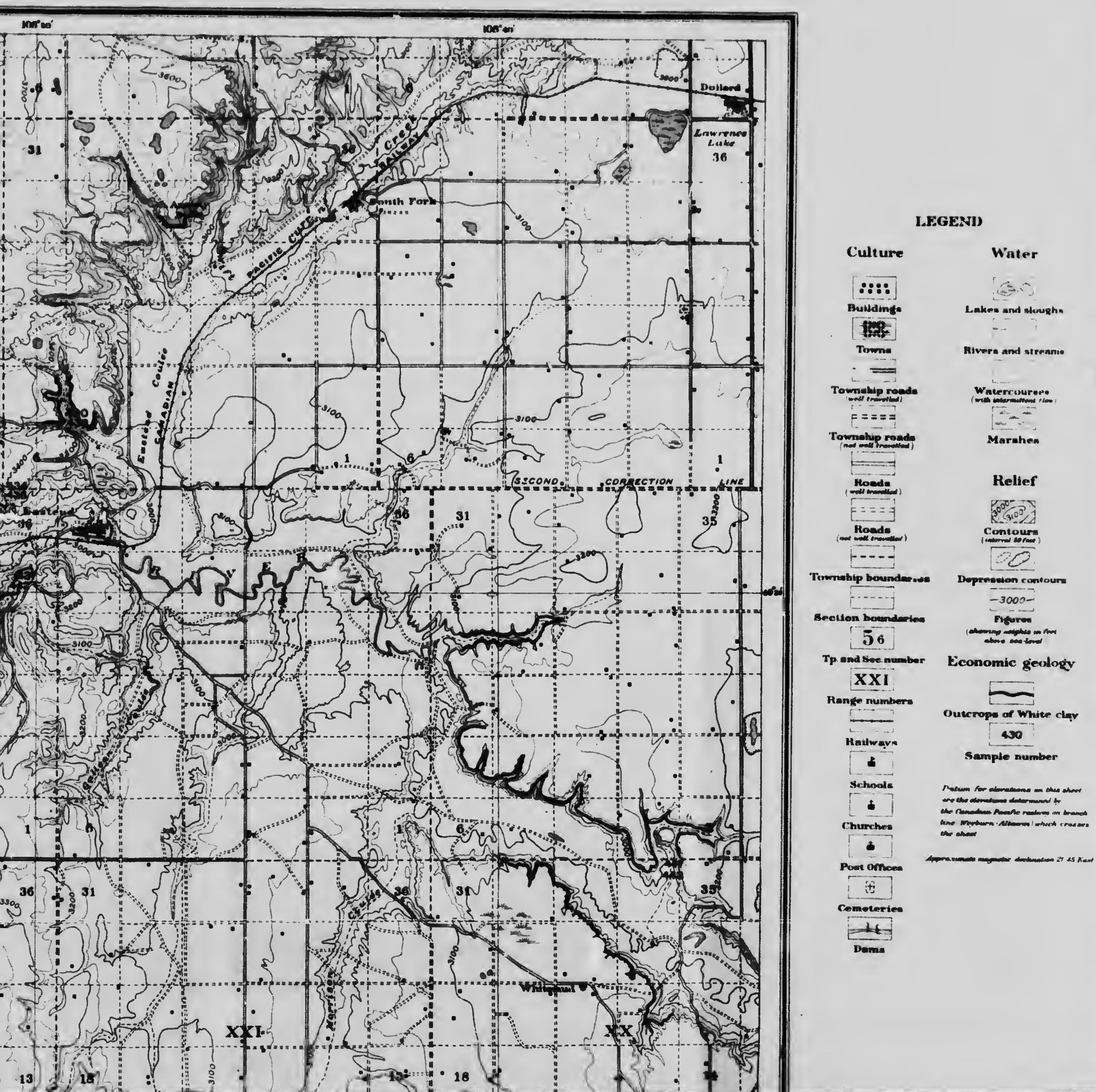
HON. MARTIN BURRELL, MINISTER, R.G. McCONNELL, DEPUTY MIN

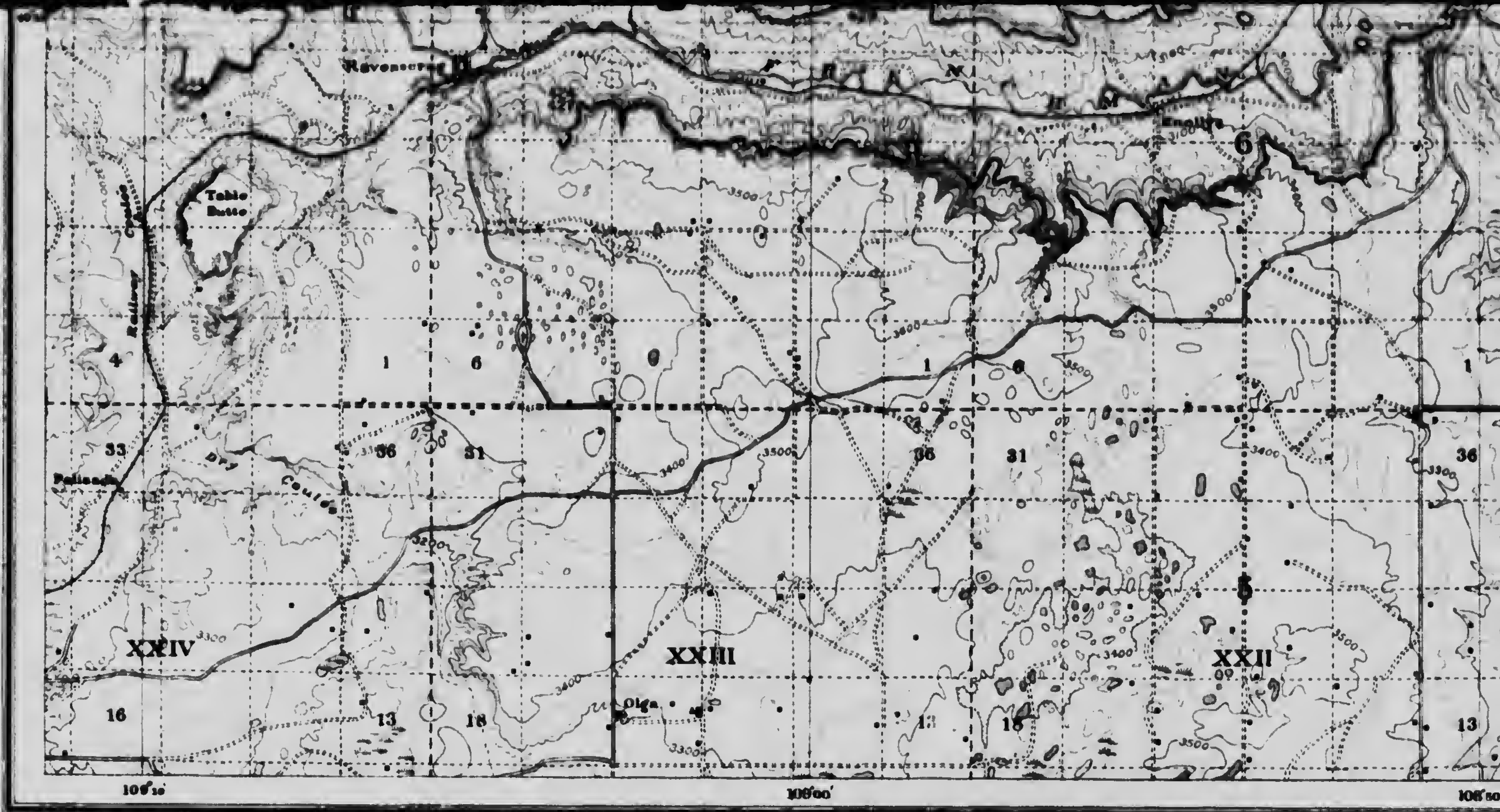
EUGENE HAANEL PH.D. DIRECTOR

1917

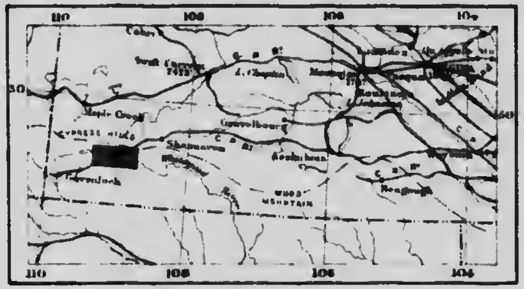
NES

DEPUTY MINISTER





H. E. Baine, Chief Draughtsman
L. H. S. Pereira, Draughtsman



Scale, 100 miles to 1 inch

SOUTHERN SASKATCH

CYPRESS HILLS SHEET

SHOWING OUTCROPS OF

THE WHITE CLAYS

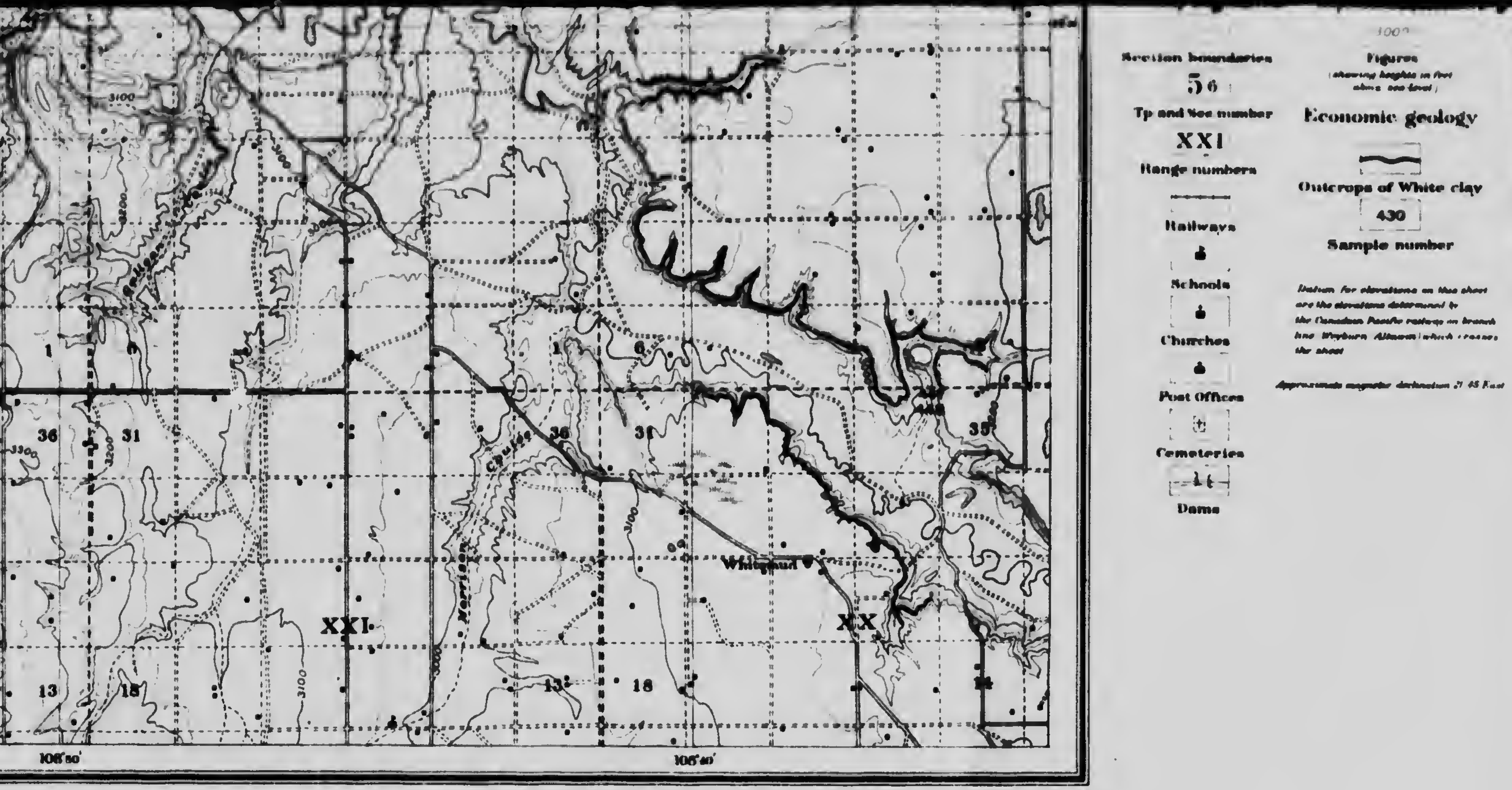
NEAR EASTEND, ALONG VALLEY OF THE FRENCHMAN

Scale $\frac{1}{96{,}000}$

MILES

2 1½ 1 ½ 0 2

Note For practical purposes assume 1½ MILES TO 1 INCH



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NCHMAN RIVER

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