PROVINCE OF SASKATCHEWAN

DEPARTMENT OF NATURAL RESOURCES

HON. J. H. BROCKELBANK, MINISTER C. A. L. HOGG, DEPUTY MINISTER

RESOURCES UTILIZATION BRANCH
A. J. WILLIAMS, DIRECTOR

TECHNICAL AND ECONOMIC SERIES REPORT NO. 1

CLAY RESOURCES

Of

SASKATCHEWAN

By

W. G. WORCESTER

REGINA
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FOREWORD

By A. J. WILLIAMS

Director, Resources Utilization Branch

DEPARTMENT OF NATURAL RESOURCES

The appearance of this very comprehensive report by Professor Worcester, covering research and exploration on Saskatchewan clay through the period of 1921 to 1947, will be welcomed by many who have had occasion to read previous brief reports by this author, touching on small portions of the information here included. For many others, unfamiliar with this province's unique position in the Dominion as a source of high grade clays, the report should prove to be an interesting introduction to one of our important resources. The vast amount of information compiled by Professor Worcester has already proven extremely useful to the Department in the expanded ceramic research and development program which the government has carried out since 1947. Since this present program is partially a continuation of the research described in this report, it might be of interest to mention recent changes in the plan of attack on the problem of developing the province's clay resources.

The major change has been an acceptance of the need to spend some money in proving up worthwhile reserves of consistently good clay, before any major development of the deposits can take place. To accomplish this end, the Department has, through the Resources Utilization Branch, purchased a clay coring drill and set up a ceramic control laboratory at Regina. Both have been in operation for two years, and as a result, much of the previous work has been brought forward to the logical commercial or industrial conclusion.

The laboratory at Regina is equipped with a clay washing line, crushers, pulverizers, ball mills, a de-airing extrusion machine, two kilns capable of attaining cone 12 temperatures, some small pottery-making equipment, and the various small testing apparatus required for checking strengths, shrinkage, warpage, workability, and other important characteristics of clays. There is no duplication in the research efforts between the Ceramic Department at the University and the Regina Laboratory of the Resources Utilization Branch. The Regina work is tied to the drilling operations and the needs of various present and potential consumers of Saskatchewan clay; this type of control work is impossible at the University where priority in use of equipment must at times be given to the scholastic program. On the other hand, much valuable long-term research can be accomplished more adequately at the University; their ceramic staff is continuing with such basic projects under the program and general supervision of the Saskatchewan Research Council.

It is hoped that Professor Worcester's report may be of value and interest to a broad section of the public, as well as providing a firm foundation of factual information on which the future Saskatchewan ceramic industry may be based.

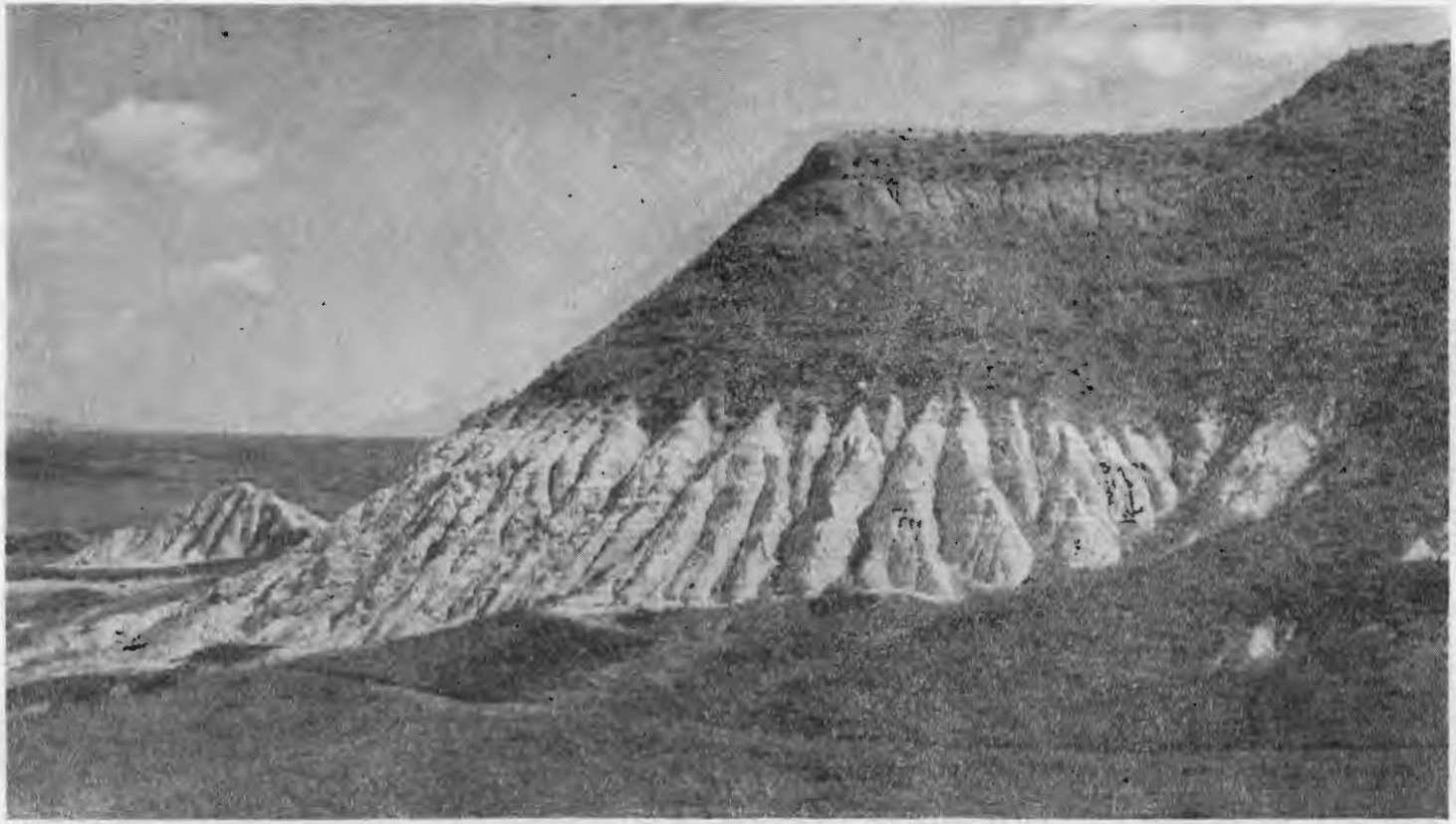
CONTENTS

MAPS

FIGURES

TABLES

PHOTOGRAPHS



KAOLINIZED SAND BEDS AT KNOLLYS, SASK.

LETTER OF TRANSMITTAL

To: THE HON. J. H. BROCKELBANK,

Minister of Natural Resources.

SIR:

It is with much pleasure that I submit herewith my report on the clays and shales of Saskatchewan which has been prepared through the authorization of your Department and its former Minister, The Hon. J. L. Phelps. The work has been made possible through the co-operation of the Department of Natural Resources and the University of Saskatchewan.

In the report there has been recorded certain data collected and observations made by the author over a great many years while head of the Ceramic Department of the University, and while engaged on a survey of the clays, shales and other ceramic materials of the province. It was deemed advisable by your Department that the material for the report be brought together prior to his final retirement from active ceramic duties in the Province and University: otherwise much of value would most likely have been lost.

In the preparation of the report no attempt has been made to go into details regarding manufacturing ceramic processes and equipment, matters which are directly the concern of the trained Ceramic Engineer and industrialist. It has further not been the aim to report on all of the hundreds of samples which have been collected and examined during the past 26 years (over 2,200) but rather to list general average samples of each type, and to direct attention to the areas where they occur, such that much time in the future may be saved to those in search of certain types or kinds of clays.

In addition, observations and viewpoints have been presented in the matter of more economical means of burning with lignite in the hopes that this local fuel can be more widely used for ceramic purposes than is the case at present. Other matters have been touched upon and are offered in hope that they may prove useful to the future of ceramics in the province.

Very respectfully,

W. G. WORCESTER,

Professor Emeritus.

INTRODUCTION AND SCOPE OF REPORT

The industrial mineral resources of Saskatchewan are many, and for the most part may be considered as being inexhaustible; particularly is this so in connection with the clay resources, the subject of this report. Past use and development of the main industrial mineral resources, with a few exceptions, has not been very great, for several reasons, (1) the newness or pioneer period of the province, (2) restricted markets or demand, or in some instances, (3) a lack of knowledge regarding their occurrence, quality, properties, and possibilities. This is particularly true in the case of clay and shale resources of the province, except in a few cases where they had been used for the production of structural wares since the early days of the west, and, in a more limited way, some of the higher grade clays which were taken from the province for use elsewhere.

It was not until 1921 that the Provincial Government and the University mutually agreed that a survey and examination of the clays and shales should be made, and that a department of Ceramic Engineering should be established at the University. This not only provided the equipment and staff to conduct the necessary field and laboratory work but also provided a course in Ceramic Engineering for the training of men as specialized engineers in the particular field, it being full well realized that technically trained men would be necessary to a safe, orderly, and economical development of the clays and other ceramic materials, such that further money should not be lost in the future, as was not uncommon in the past, through clay product plants being located on wholly unsuited clay or through other unfavourable conditions. Hence during the early part of 1921 the author of this report was engaged by the University and the Provincial Government to open the Department of Ceramics at the University, to lay out and conduct the course in Ceramics, and to take charge of the desired field work and laboratory nvestigations. During the 27 years which have passed since that date a vast amount of information concerning the clays and other allied industrial minerals of the province has been obtained through his work and observations in the field, and through research and laboratory investigations. In order that this information would not be lost upon his retirement from the University it was thought advisable to prepare the same in the form of a report for publication. In addition to this volume which reports on the clays and shales, a second one is planned to record much that is known in connection with a number of the other industrial minerals, such as sodium sulphate, potash, bentonite, volcanic ash and others.

The present report comprises a brief discussion of the geology, the origin, occurrences, distribution, classification, general properties and uses of the clays and shales of the province. In addition the author presents certain opinions and conclusions which he has arrived at through his long study of the clays and the problems which have confronted the manufacturers of clay products in the province during the past. It is all presented in the hope that it may prove helpful in the matter of future studies of the clays and their industrial development to better meet outside competition.

No attempt has been made to make the report highly technical; the author felt that it would be of more value to a greater number if presented in terms more easily understood by the practical man of the industry and others not possessed of a technical and scientific training in Ceramics. For their benefit and interest, the origin of clays, their classification, a discussion of types and their uses, etc., has been, it is true, all too briefly treated. It is felt, however, that sufficient has been presented along those lines to prove of interest and possibly to create a desire for further study.

In the presentation of the data concerning the properties of the several types of clays investigated over the many years, time would not permit, nor would it have added to the value of the report, to have included each and every sample of the hundreds collected and tested. A sufficient number of each type has been included to cover the general range and the average of each. This information plus the location of each sample should make it possible for those seeking a suitable clay or clays for a definite purpose to proceed to the areas and deposits in which they occur. From then on it would be to their own interest to have a careful examination made of the deposit as a whole to establish its extent and uniformity of quality, and to conduct the particular tests necessary to their own needs.

For the most part the past work has been confined to investigations of the clay formations and deposits in southern Saskatchewan, the collecting of samples from same followed by the conducting of major preliminary tests for clays as set forth by the American Ceramic Society. These tests are concerned with both the raw and burned properties of each sample; they include hardness, plasticity, working properties, drying conditions and shrinkage in the unburned state, followed by burning tests from low to elevated temperatures to determine the burned colour, hardness, shrinkage, absorption, porosity, freedom from scum, and other equally important properties.

With the above data available, clays can be classified into types, and their uses indicated. Such preliminary tests are primary and necessary; they save much time and money in the matter of selecting for further study those clays possessed of the best or most favourable properties for certain wares or uses, and in the avoiding of further work and attention on those of little or no promise. Though in this connection it should be borne in mind that while preliminary tests permit of culling out the poor undesirable clays, they

do not take the place of a final or complete test. In such cases a sufficiently large average sample of the clay is taken, from which preferably full-sized ware may be made under as near commercial conditions as possible; that is, if the preliminary test proves the clay to be of interest for structural wares, pottery or other kinds, and is reported accordingly. Not only does a preliminary test permit the dividing of clays into types but it goes much further in that from the data so obtained it permits the sub-dividing of them into groups or classes; that is, those indicated to be of interest for common brick can readily be segregated from those offering possibilities for face brick and other high grade structural wares. Further, those clays which prove to be of the pottery type can definitely be classed as yellow ware, stoneware or whiteware clays, and, by the still further studies of their properties each of these may be divided into their interest for more than one kind of ware.

It has been deemed advisable to include as an appendix to the main report a brief review of those samples collected from year to year, with comments by the author on the possible uses and importance of certain ones and to clearly indicate those of no further interest so that they may be avoided in future work. For this purpose a goodly and representative number of the samples collected and tested from year to year are briefly presented in table form. The location of each deposit or bed is given and sufficient data regarding the unburned and burned properties of each is provided so that those familiar with clay testing data can readily select the kind or type of clays desired. In practically every case the author has commented on the general quality, the possible uses, and importance of each as being of some assistance or guidance.

It is to be kept in mind that in the preliminary testing of clays that it is largely through experience that it is possible to judge the differences in the matter of burned colour, shrinkage, hardness, checking and other properties of small trial pieces burned in a few hours and usually cooled quickly, to those of the same clay when burned in large commercial kilns under long hours of heat and slowly cooled. In general, the colour or shades will be better in the latter case, the shrinkage will be higher and absorption lower. Furthermore, some clays may become distorted or bloated when fired in a test kiln but would not do so under the longer slow firing time of a large kiln under usual firing conditions. It is also to be taken into account that while many of the Saskatchewan clays, particularly the ball clays, have been mentioned as containing or showing dark specks when burned; in this connection the potter or user of such clays well knows that all whiteware pottery bodies are blunged into slip form, passed over magnets and through very fine screens in their preparation for use. It is thus quite possible that the speck-forming impurities in the ball clays will be removed in most cases; in others special treatment may be necessary.

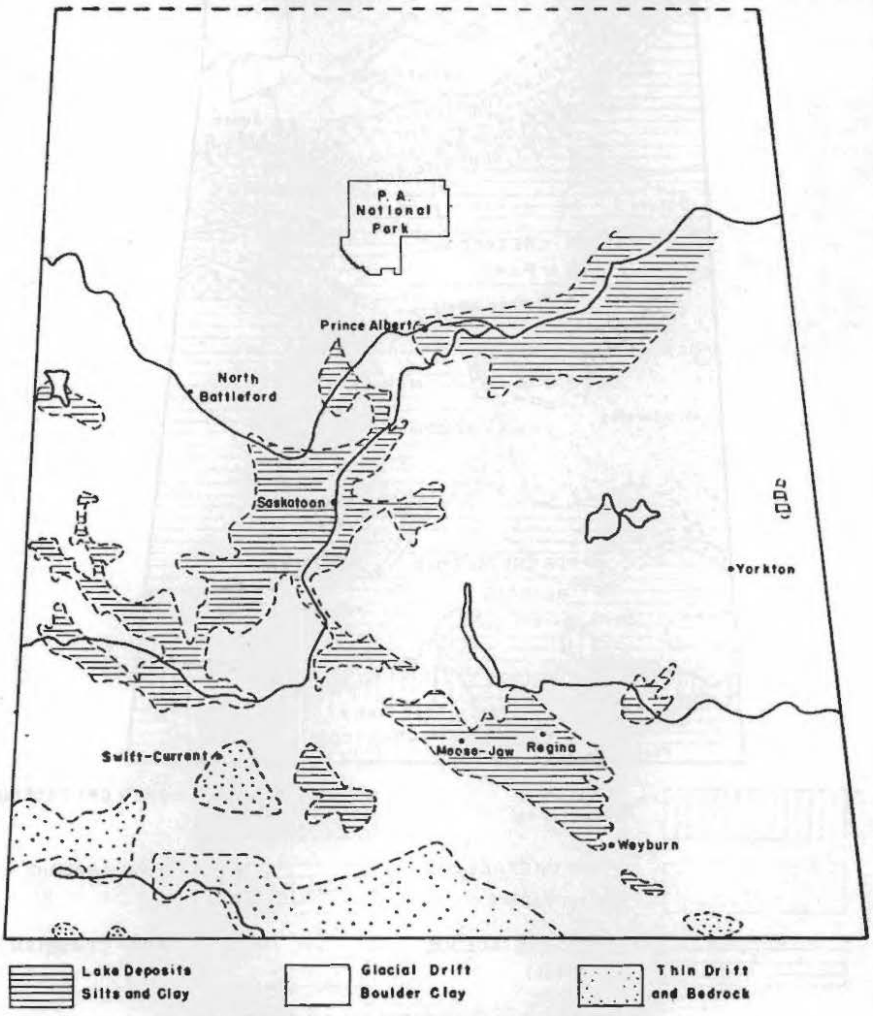
It may be well to mention that the numbering system used by the author in connection with all samples collected from year to year was that of placing the year first and the serial number of the sample second, for instance, sample No. 3026 at once shows that it was the 26th sample collected in 1930, while sample No. 3904 clearly indicates that it was the 4th sample collected in 1939, and thus for all years from 1926 forward.

1. General Geology and Topography of The Clay-Bearing Formations of Saskatchewan

GEOLOGY

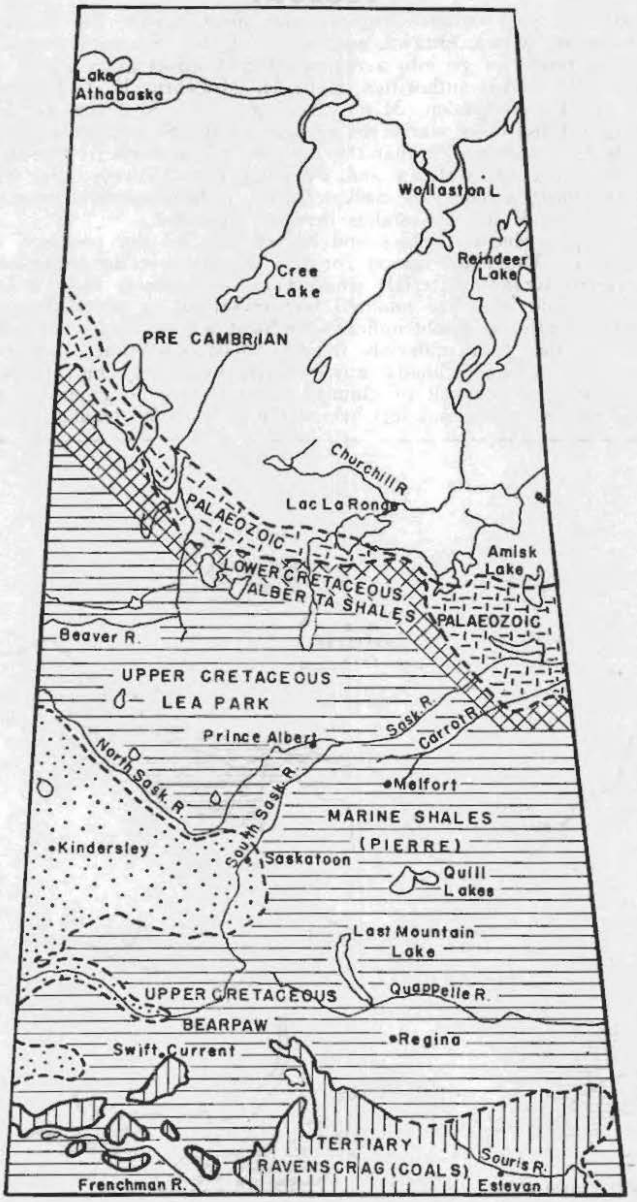
In view of the past detailed reports and memoirs by the Bureau of Economic Geology, Department of Mines, Ottawa, on the geology of Saskatchewan, there seems little need at this time to repeat or go into a review of that information which is now available, prepared by such well known authorities as F. H. McLearn, F. J. Fraser, L. S. Russell, W. P. Warren, R. T. Wickenden, M. Y. Williams, W. S. Dyer, G. M. Furnival and others. Therefore, in those cases where the geology of the Saskatchewan clays is of primary importance it is to be recommended that the reports and memoirs of the above men be consulted, particularly those of McLean and Furnival (8). However, for those not deeply concerned with the basic geology of Saskatchewan, a brief general review of same may prove ample, or at least of interest, and is here so presented.

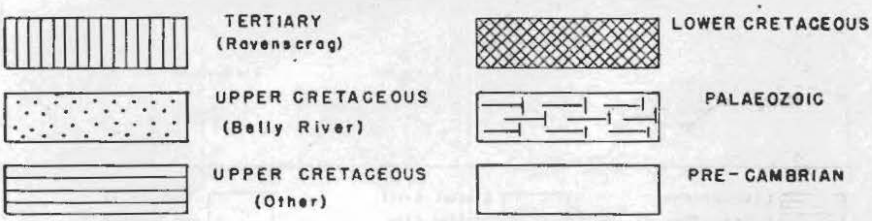
Other than in the deeper valleys and higher hills of the province, outcrops of bed rock are not common. The chief reason for this condition is the heavy mantle of glacial drift and other recent surface materials which vary in thickness from a few feet in some cases to as much as four and five hundred feet in others, as revealed occasionally by the drill. These unusual depths no doubt indicate the locations of pre-glacial valleys which were completely filled by the drift materials during Pleistocene time, that period when the greater part of what is now Canada was covered by slowly moving ice sheets, either advancing or retreating as a result of climatic changes over long periods of time. At the last retreat of the glaciers there was left behind the present day blanket of glacial materials,



MAP NO. 1 SURFACE SOIL GEOLOGY

boulder clays, the field rocks of the prairies, lake clays, sands and gravels, the three latter resulting from a grinding, washing, transporting and sorting of the boulder clay by the great quantities of water from the melting ice. The lake clays in some instances are found useful; an example are those at the Bruno Clay Works near Bruno, Sask. In addition





MAP NO. 2 GENERAL GEOLOGY

to the glacial or boulder clays there are other present day surface clays in the province; they are the flood plain clays deposited from overflowing streams of muddy waters, particularly of those as far back as late glacial time. In connection with the glacial and other related deposits, Map No. 1, taken from Soils Survey Report No. 10 of Saskatchewan, (10) shows approximately the very large area of the south half of the province which is blanketed with glacial drift and boulder clay, and that of the general areas east of Prince Albert, near Saskatoon, Rosetown, Regina, and Moose Jaw deeply covered with lake clays. sands and silts.

In the extreme south where there are deep valleys which were cut down through the drift beds and into lower formations, there are many exposures of pre-glacial bed rock materials such as sandstones, shales, coal and clays. The Tertiary, where present, occurs just below the glacial and other surface materials; however, only a comparatively small part of the province is occupied by the Tertiary, the beds or formations of these being in the extreme south, along the international boundary, and extending from Manitoba on the east to Alberta in the west except where absent due to past erosion, which is particularly the case in the west. The Tertiary is of much interest in that it carries coal and some of the more important clays, those known as the Willowbunch, of which there are two types, plastic and sandy clays which burn to light shades and are semi-refractory, differing therein widely from the associated beds of clays and shales above and below them. Reference should be made to the Regina Sheet, No. 267A (7), and to the other parts of this report for the areas and more exact locations of the Willowbunch clay occurrences.

Immediately below the Tertiary is the Upper Cretaceous, which is subdivided into or composed of a number of formations. Its general distribution may be noted from the small reference map No. 2 page 16. The legend shows it to be made up of the Lower Ravenscrag *, the Whitemud, the Eastend, the Bear Paw, Belly River, Lea Park and Alberta. The Bear Paw and Lea Park, both marine, are separated by the non-marine Belly River in the west of the province, whereas more easterly there is a continuous sequence of the marine beds that have been named the Marine Shale Series. Though most of the several formations of the Upper Cretaceous are of ceramic interest, the Whitemud member ranks first in that within it there are the highest grade clays known to occur in the province. These clays range from the light burning semi-refractory stoneware clays in the Cypress Hills area at the west to the light and white burning refractory clays farther east; in so far as known the two types of clay do not overlap, or occur together in the same areas. There is, however, a wide gap between them where glacial erosion removed all traces of the Whitemuds; it may have been within that area that the gradual transition took place.

The Eastend, underlying the Whitemuds, is for the most part composed of light yellowish-green siliceous beds of sands, silts and grey shales. The latter offer little for their use in ceramic wares, in that they tend to crack badly during the drying stages. The Bear Paw below the Eastend is mostly made up of marine fine grained shales, dark in shade and of questionable value for ceramic use.

The Belly River is mostly non-marine; it carries useful coal seams, sandy members and shale beds, some of which are of material interest for structural clay products. The chief outcrops, which are somewhat limited, are in the west central area, roughly between the two branches of the Saskatchewan River from the Alberta border to near Saskatoon at the east. To the north it gives way to the Lea Park and eastward to the before mentioned Marine shales. The Lea Park is marine in origin and consists mostly of dark shales in the lower beds, with a change to lighter shades near the top where there are zones of fine grained sands and sandy shales which may offer promise for industrial use.

To the north of a line passing roughly through Meadow Lake, Prince Albert, and Melfort and south-eastward to Manitoba is a fairly large area where the Alberta formation is shown as the bedrock, though much of the area is under drift and other recent materials, and outcrops are quite limited. It is marine in origin, for the most part dark grey in colour and is largely non-calcareous, though more so to the east. Some of the beds or members of it which have been examined in a limited way did not yield much of promise for use as a ceramic material.

In the southern part of the province the Lower Cretaceous is so far down that its presence has not been proven other than by a number of deep bore holes. There are definitely no outcrops of it other than along the Clearwater River in the far north west, south of Lake Athabaska, or roughly three hundred miles north of Lloydminster. Its distance from rail at that point places it well out of the range of any possible interest in the near future.

At present the geology of the province of greatest interest to the ceramist is that of the formations in the Tertiary and that of the Frenchman, Battle, and Whitemud of the late Upper Cretaceous. It is in those formations that higher grade clays are known to occur, though in addition, much remains to be learned regarding members of the Belly River, Lea Park, and Alberta formations.

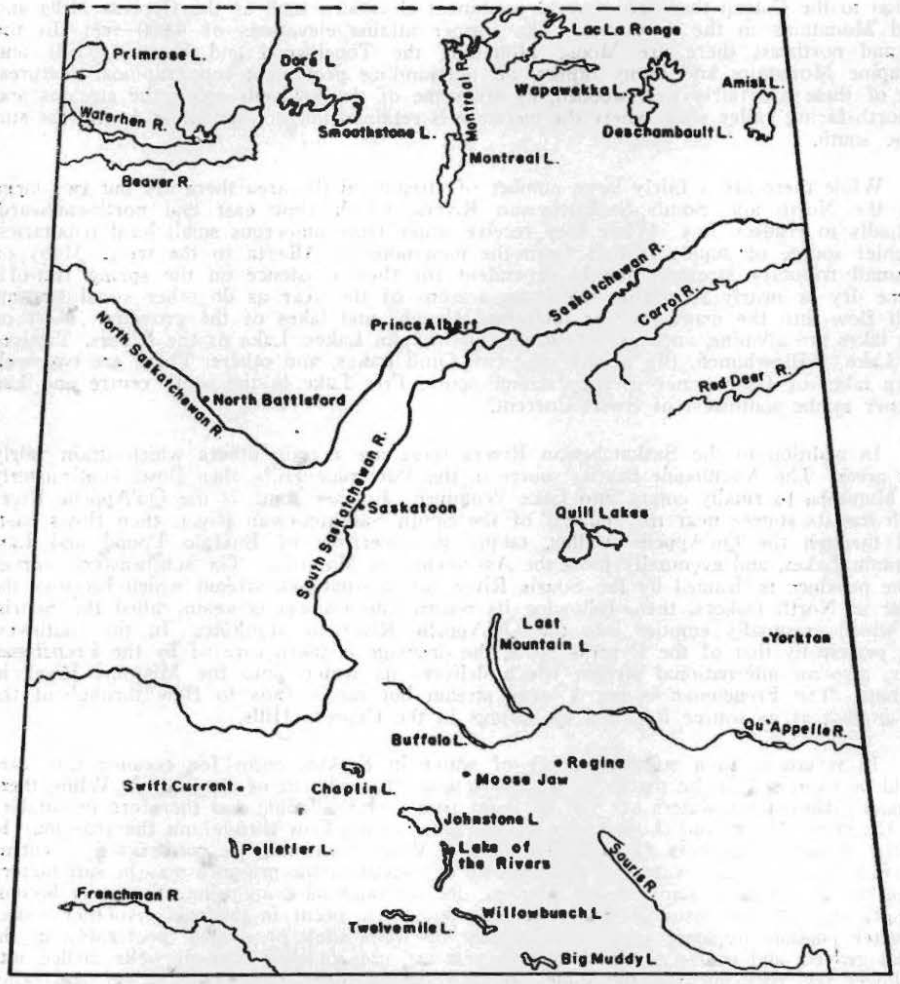
* Now called the "Frenchman" and "Battle" formations.

TABLE I

TABLE OF FORMATIONS

Period	Epoch	Formation	Thickness Feet	Lithology
Quarternary	Pleistocene			Boulder clay, lake silt, sand, etc.
		Erosional unconformity		
Tertiary	Oligocene	Cypress Hills	50–550 +	Conglomerate, sandstone, marl, clay, etc. Continental deposits.
		Erosional unconformity		
	Paleocene	Ravenscrag	227 +	Buff and grey sand, silt and clay, lignite, etc. Non-marine.
Cretaceous	Upper Cretaceous	*Frenchman	10–150 +	Sandstone; Triceratops fauna. Non-marine.
		Erosional unconformity		
		†Battle	20–30	Bentonitic shale, silt, sand. Non-marine.
		Whitemud	33–45	White to grey clay; sandstone; silt. Non-marine.
		Eastend	70–120	Sand, silt, clay; lignite. Marine to non-marine.
		Bearpaw	940–1,000	Dark marine shale; Belanger and Oxarart sandstone members.
		Oldman and Foremost	585–820	Sandstone, shale, and lignite, sandstone predominating. Non-marine. Sandstone, shale, and lignite, shale more abundant. Interbedded marine and non-marine.
		Lea Park: Pakowki	500–560	Dark grey marine shale.
		Lea Park: Milk River	300–310	Chiefly shale; sandstone; sandy shale; chert pebbles.
		Formations penetrated by deep wells but not exposed.		
		Alberta	1,100–1,400	Dark grey marine shale.
	Lower Cretaceous	Marine	300–330	Dark grey shale; sandstone.
		Non-marine	110–200	Dark grey, red, and green shale; lignite; salt and pepper sandstone.
		Erosional unconformity		
Jurassic			380-520	Shale; limestone, dense; sandstone.
		Erosional unconformity		
Mississippian	Big Snowy group		?	Limestone, sandstone, shale.
	Madison	Mission Canyon	?	Limestone, crystalline, light coloured.
	Madison	Lodgepole	?	Limestone, dark, argillaceous; sandstone; shale.
Devonian or Mississippian	Exshaw		10-50	Shale, black, non-calcareous
Devonian	Three Forks		?	Shale, green; dolomite.
	Potlach		?	Anhydrite.
	Jefferson		?	Dolomite, crystalline; anhydrite.

*—Formerly Lower Ravenscrag.
†—Formerly No. 4 Zone of the Whitemud.



MAP NO. 3 SASKATCHEWAN STREAMS AND LAKES

TOPOGRAPHY

The area included in this report is approximately that of the southern half of the province, and comprises about 150,000 square miles. It extends from Manitoba on the east to Alberta on the west and from the states of North Dakota and Montana on the south to 55° north (roughly township 70 if the survey extended that far). In general the area falls within that region known as the plains, though it is far from being a monotonous flat prairie in that it is broken by numerous deep valleys, escarpments, plateaus, hills, rivers and lakes. While the general slope is east and north east, it is broken by a prominent escarpment known as the Missouri Coteau, a long upland 2,000 to 2,500 feet above sea level, which in places attains elevations of 200 to 500 feet above the prairie levels. It enters the proovince at a point on the international border south of Weyburn, and then continues in a general northwesterly direction for many miles across the area. For the most part the east margin or face is more pronounced than that to the west where gentle slopes prevail. In addition to the Coteau there are several prominent elevations such as the Cypress Hills and Wood Mountains in the southwest. The former attains elevations of 4,000 feet. In the east and northeast there are Moose Mountain, the Touchwood and Pasquia Hills and Porcupine Mountain, and many others, all outstanding prominent topographical features. Most of these are fairly well wooded, as are some of the lowlands along the streams and the north-facing valley sides where the moisture is retained longer than those facing the sun to the south.

While there are a fairly large number of streams in the area there are but two large ones, the North and South Saskatchewan Rivers, which flow east and north-eastward, eventually to Hudson Bay. While they receive water from numerous small local tributaries, the chief source of supply is that from the mountains in Alberta to the west. Many of the small tributary streams, mainly dependent for their existence on the spring run-off, become dry or nearly so during the latter seasons of the year as do other small streams which flow into the many interior undrained sloughs and lakes of the province. Most of these lakes are alkaline, such as Johnstone and Chaplin Lakes, Lake of the Rivers, Twelvemile Lake, Willowbunch, Big Muddy, the two Quill Lakes, and others. There are two well known lakes of fresh water in the extreme south, Fife Lake in the south centre and Lac Pelletier to the southwest of Swift Current.

In addition to the Saskatchewan Rivers there are certain others which drain fairly large areas. The Assiniboine has its source in the Porcupine Hills, then flows southeasterly into Manitoba to finally empty into Lake Winnipeg. Further south is the Qu'Appelle River which has its source near the "elbow" of the South Saskatchewan River, then flows eastward through the Qu'Appelle Valley, taking the overflow of Buffalo Pound and Last Mountain Lakes, and eventually joins the Assiniboine in Manitoba. The southeasterly corner of the province is drained by the Souris River, an international stream which becomes the Mouse in North Dakota, then, following its return into Canada is again called the Souris, and which eventually empties into the Qu'Appelle River in Manitoba. In the southwest area, principally that of the Cypress Hills, the drainage is taken care of by the Frenchman River, also an international stream which delivers its waters into the Missouri River in Montana. The Frenchman is not a large stream but rarely fails to flow throughout the year in that at its source it is fed by springs in the Cypress Hills.

In reference to a suitable supply of water in Saskatchewan for ceramic use, care should be exercised in the matter of sufficient quantity and that of its quality. While there are many lakes, their waters are for the most part highly alkaline and therefore unsuitable; only the larger rivers and those of the smaller ones which flow throughout the year may be counted on as safe sources of a suitable supply. While dams may be constructed to entrap a sufficient supply, such waters in the southern dry areas of the province may be satisfactory in the spring and early summer, but later on, due to continual evaporation, they may become strongly alkaline and unsuitable; this has been known to occur in the past. Another source of water possible in some areas may be that of wells sunk or drilled, preferably in the glacial gravels and coarse sands. The prospects are not so good through wells drilled into the lower bed rock such as the shales in the Eastend, Bear Paw, Belly River and other formations, where, in most cases, the fineness and tightness of the shale particles are such that they do not contain water, or that such limited quantity as may be present is too restricted in its movement to maintain a continuous supply. In general, a water obtained from such sources in the prairies is likely to be salty or alkaline. Though the shale beds are likely to prove unfavourable as sources of water, there are known instances where a supply has been found to occur in shale formations, either from zones or beds of sandy shale or more likely from underground cracks or crevices acting as large storage reservoirs within the beds as a whole.

While as before mentioned, there are wooded areas in the province, and a large lumber industry exists in the north part, the forest areas where important clays have been noted is relatively barren of forest growth.

2. Technology of Clays and The Clay Industry

The term "clay" is commonly associated with those earthy materials whose most noticeable property is that of plasticity when wet, the property which permits of shaping or reshaping a mass of soft clay into any desired form which upon being dried will retain that shape, though only so long as the article is held in the dry condition. If water is added in sufficient amounts, a clay may repeatedly be brought back to the plastic state. A further very important property common to most clays is that they can be vitrified; that is, made permanently hard and durable through subjecting them to sufficiently high temperatures. There are, however, some of the higher grade clays which cannot be vitrified within the range of any practical temperatures; many of these are notwithstanding, very important for certain uses.

A discussion of the general properties of clays will be found further on in this report.

ORIGIN OF CLAYS

In order to place before the general reader of this report a comprehensive insight into the reasons why there are certain clays in Saskatchewan and why others are absent, it seems desirable to discuss the origin of clays, a subject which has been dealt with in detail by numerous authors in the past. For that reason it is not deemed necessary at this time to repeat, other than quite briefly, that which is now accessible to those further interested.

In most cases the average person who has given little if any thought regarding the origin of clay would be of the opinion that it has, from the beginning of time, been in the same condition as it is today; that is, having originated as a primary material. This, however, is not the case, in that clays are secondary minerals which have been formed through the hydrous alteration of certain parent crystalline rocks like the feldspars, granites, hornblende and other complex silicates. In order that any of these may be altered to clay, it is first necessary that they have in their composition silica and alumina, usually occurring as silicates. It is then necessary that a long period of weathering take place to break down the original rock mass and to permit the necessary chemical and mineralogical changes to take place. The following, taken from Wilson (27) covers the usual active alteration agencies.

"1. MECHANICAL CHANGES OR DISINTEGRATION:
   a. Erosion and denudation. (Water, wind and ice.)
   b. Temperature (Freezing water, heat and cold.)
   c. Plant and animals.

2. CHEMICAL CHANGES OR DECOMPOSITION:
   a. Oxidation.
   b. Hydration and dehydration.
   c. Solution.
      Water, pure or acidulated.
      Pneumatolytic action of hot gases and liquids.
   d. Deoxidation."

In most cases the alterations have taken place *in situ*; that is, at the location of the parent rock, though in some cases like those of certain clays in Southern Saskatchewan, the primary material in the form of sand grains was transported many miles by water before coming to rest and undergoing its ultimate transformation (kaolinization) into the clay as now found.

A common type example of rock weathering to clay might be that of granite, a rock usually composed of three minerals, quartz, feldspar and mica. Their compositions are assumed in the present case to be as follows:

Quartz - SiO_2

Feldspar - $K_2O.\ Al_2O_3.\ 6SiO_2$

Mica (Muscovite) - $K_2O.\ 3Al_2O_3.\ 6SiO_2.\ 2H_2O$

An examination of the granite in its solid rock form would reveal the presence of the three minerals; of these the quartz is highly resistant to all weathering agencies. The mica usually remains unaltered. The feldspar, on the other hand, following its disintegration is quite easily attacked and ultimately is altered to kaolin (clay substance) as set forth by the following molecular equation: $K_2O.\ Al_2O_3.\ 6SiO_2$. (Feldspar) plus weathering plus H_2O (water) plus CO_2 (carbon dioxide) = $Al_2O_3.\ 2SiO_2.\ 2H_2O$ (Kaolinite) plus 4 SiO_2 (silica) plus K_2CO_3 (Potassium Carbonate).

In the above, the feldspar as revealed by its molecular formula is a silicate composed of potash, alumina and silica. There are six molecular parts of the latter to one each of the potash and alumina, the ratios of components of pure crystalline feldspar which usually comes in the form of dykes entrapped in other rock. The veins or dykes of feldspar are, in some cases, many feet wide and of untold depths. In others, the width of the dyke may, in places, be reduced to a matter of a few inches.

In the case of granite rock, the one selected as a common example of weathering to clay (kaolin), the feldspar portion occurs in its crystalline form intermixed with the quartz and mica; notwithstanding, its alteration to clay will follow the same general lines as set forth above.

First the granite rock as a whole will be broken down by weathering agencies such as the freezing and thawing of water within small cracks or crevices, thus opening the cracks both wider and deeper and thereby permitting more water to enter and to greater depths each time there was a sufficient temperature change from thawing to freezing. In some cases, trees and other vegetation roots assist in the mechanical break down of the rock as a result of their entering the cracks, then, due to expansion by growth, further widening the cracks.

With the mechanical reduction of the rock, certain chemical changes or decomposition are then possible from the action of acidulated water, organic and carbonic acids, oxygen, etc., the result being that the feldspar is so altered and that the K_2O (potash) is released. It then reacts with H_2CO_3 (carbonic acid) to form K_2CO_3 (potassium carbonate), a soluble salt removable by percolating waters. There would then remain the alumina and silica; these in turn plus water develop into a new combination where there is an excess of silica left over from that necessary with the alumina to form clay. In this case, the molecular ratio of the alumina to the silica is one to two, thereby setting free the extra four molecules of silica, not as quartz but in the form of silicic acid in an amorphous gel condition which is eventually removed. The end product of all changes and reactions is therefore a hydrous silicate of alumina, in the form of clay substance. Kaolin, if dry, will usually be white, granular or powdery and lacking in plasticity when wetted. In addition to the white clay substance there will also be present the original quartz and mica of the parent granite rock. These must be removed from the kaolin portion before it can be used industrially as china clay.

In addition to the above brief outline regarding the formation of clay from feldspar, it is desired to draw attention to the fact that there are two main or primary conditions under which past alterations have occurred. First: as described above, where the kaolinization began at the surface and has, during the passing of many centuries, been slowly and continuously working its way downward until at present some deposits are very deep. Naturally, under those conditions the greatest degree of alteration is near the top or surface where the time for the reactions has been longest. At greater depths partially or semi-decayed rock will be found and at still greater depths the solid, wholly unaltered rock remains. In many cases both kaolin and rock are found intermixed at zones not far removed from the surface, a condition not easily explained.

Secondly: in a few cases, particularly those occurrences of kaolin at Cornwall, England, in Bohemia, and near Spokane, Washington, the alteration of the rock has been from deep-seated sources upward rather than downward. In such cases, there was at no time any surface weathering to facilitate the breaking down of the hard rock. The alteration reactions resulted largely from upward moving hot acidulated waters or steam and no doubt gases which reacted on certain parts of the parent rock to form kaolin, or kaolinite, the latter being the pure crystalline clay mineral.

In those cases where the original rock material was free of iron in its composition, the kaolin formed from same would be white or nearly so. Where iron bearing minerals were present, if in sufficient quantities, then the clay (kaolin) would not be white; instead it might be yellowish, rusty, pink or some shade of red, and in most cases is not suitable for any but the lower grade clay wares where colour might be permissable.

In addition to the formation of clay from the more pure types of rocks like the feldspar, granites, etc., there are other clays and clay-like minerals which have resulted from the alteration of lower grade parent materials. Among these may be listed Basalt and Volcanic Ash; these, under certain conditions, break down into clays which are usually plastic and are red or buff burning. Volcanic ash is at times the source of bentonite, a clay-like mineral of unusual properties, such as having a large expansion when wetted, forming non-settling colloidal suspensions in water; its drying shrinkage is excessive, such that it cracks badly during drying. These and other reasons prevent its use as a clay, but it does, nevertheless, find a rather wide use in ceramics.

It has not been possible for primary kaolin to be formed in Southern Saskatchewan. The reason for this arises from the total absence of the necessary types of rock, as may be readily seen by reference to the geology of the area. Sedimentary materials only are present. There are, however, the kaolinized sands of the Whitemud beds in which the alterations took place subsequent to the deposition of the sands, sands which originally consisted largely of grains of feldspar, quartz and mica plus minor amounts of other

minerals. The weathering or alteration conditions which followed were such that the grains of feldspar were altered to kaolin. The quartz, mica and some of the lesser minerals being more resistant have remained in their original condition. Strictly speaking, the kaolin which occurs in the above sands is of primary origin in so far as having been formed *in situ.* On the other hand, the feldspar sands were secondary in that they had been moved, one or more times from the primary place of their origin with little, if any, alteration other than a possible reduction in their grain size.

CLASSIFICATION OF CLAYS

It is fortunate industrially that there are many types and kinds of clays available; otherwise, it would not be possible to produce the great variety of clay wares essential to the progress of modern times. In view of the multitudinous varieties of clay, it its very necessary that there should be a means of classifying them so that they may be orderly studied regarding their origin, type, quality, uses, and that an exchange of knowledge concerning them may be more easily made. While there have been a number of classifications prepared, and used in the past by geologists and authors of clay reports, no single one has been accepted as a standard and it is not likely that it will ever be possible to prepare one which would prove satisfactory in all cases. The geologist has in most cases classified them as to their origin, their age, and general types. All this information is useful to the Ceramist as well, but he needs more: for instance, in addition to the information supplied by the geologist he is concerned with the physical properties of the clay, the chemical analysis of same, its colour when burned and some reference to its uses. The Ceramist is therefore best served by what might be called a composite classification, that is, with material drawn from the Geologist, the Chemist, the Mineralogist, and from the field of Ceramics. The first classification of the kind was prepared by Prof. Edw. Orton Jr. (M.E.)* and used in his lecture courses to ceramic students. During the many years following its early use in the classroom, it has been taken as the basis for several later classifications in modified forms. While each of these two have in particular cases proven satisfactory, it is felt in the present case that the original of Orton will prove more useful. It is therefore presented as Table No. II.

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* Founder in 1894 of the world's first school of Ceramic Engineering at Ohio State University, Columbus, Ohio.

TABLE NO. II

ORTON'S CLASSIFICATION OF CLAYS

PRIMARY CLAYS Formed *in situ*	Decomposed feldspathic rock from which most of the alkali has been removed.			The kaolin or China clay or paper clay of commerce. Found only in places where the older igneous rocks are exposed to weather.
	Decomposed feldspathic rock which has lost but a part of its alkali.			Cornwall stone used by the English and American potters. **Porzellan Erde** as used by the German and French potters. **Pe-tun-se** of the Chinese potters.
	Decomposed rocks other than feldspathic, which leave an aluminous residue.			Impure ferruginous residual clays found occasionally where basalt and other basic silicates containing alumina have decomposed. Do not furnish clays of good quality.
SECONDARY CLAYS	**SECONDARY KAOLINS**	Highly Refractory		Usually white to buff in colour in the raw and burned condition.
				May or may not be plastic. Some are quite plastic.
				Usually mixed with quartz grains of various sizes, as well as mica scales.
				Must be washed before commercially useful.
				Used for paper clay, paints and all classes of white ware, china and porcelain.
	BALL CLAYS	Moderately Refractory		Colour in raw state—buff—pink—grey—black—slate—chocolate—etc.
				Burns—nearly white, buff, or cream colour.
				Highly plastic, very fine grained.
				Usually used unwashed through for certain work it is now washed.
				Used in most whiteware, china and porcelain products
	FIRE CLAYS	Clays which will not fuse at any temperature in common use. Generally plastic, tough & strong when dried. Burn to light colour bluish, grey or white.	Highly Refractory.	Flint fire clays or chemical kaolin. Devoid of plasticity. Found generally in the coal measures.
				Plastic fireclays. Found more frequently in the later rocks than the coal measures. Often found in Cretaceous.
			Moderately Refractory.	No. 2 fireclays or bonding clays, used for common grade of firebricks.
				Stoneware and yellow ware pottery clays. Must have plasticity, and sufficient refractoriness to stand a salt glazing fire.
				Sewer pipe clays. Plasticity and refractoriness both lower than in preceding. Must stand salt glazing fire.

TABLE NO. II—*Continued*

SECONDARY CLAYS	SHALES Clays which have been deposited slowly, and in still, quiet waters.	**SHALES** Do not stand fire well .Generally vitrify at a low heat. Burn generally to a red or brown color. Exhibit strong parallel cleavage due to pressure. Often highly concretionary.	Indurated, split well.	Slates or shales from which a part of the water of hydration has been expelled by metamorphic action. Not plastic.
			Softer	Shales. Generally somewhat plastic. Concretionary structure often prominent. Lime and iron not very high.
			Less cleavage and much more concretionary structure	Shale Marls. Often stratified with limestones, and containing too much lime to work as clays, and not enough for lime.
				Black shales, impregnated with bituminous or carbon compounds. Bone coal is upper limit of this class.
				Black band iron ores. Shales in which enough carbonate of iron is present to make them valuable for ores. These generally contain carbon as well, enough to make them calcine themselves when fired.
	CLAYS	**BOG CLAYS** character marked by the influence of chemical precipitation. Do not stand heat. Not useful as clays.	Bituminous	Varying from a light colored clay up to a bone coal. Generally burn light, though dark in tint. Sometimes burn red.
			Ferruginous	Varying from common red clay up to bog iron ore or kidney ores. Concretionary structure very strongly marked.
			Calcareous.	Varying from low percent of lime up to 60 percent. Marly clays up to clayey .marls. Burn yellow or white and fuse very easily
		ALLUVIAL CLAYS Recent deposits. No structure.	Generally plastic, somewhat sandy clays, free from gravelly beds, or limestone or concretions. Very valuable for brick making. Burn red or dark color.	
	Clays which have been deposited from running water	Sandy clays.	Generally plastic clays, which are weak when dry, and easily crumble. Burn red or dark, and vitrify at low heats, and melt at high temp. When they contain vegetable mold they are called loam.	
		Clayey sands.	Generally plastic, but are without cohesion when wet or dry. Wares made from them lose shape. Burn red or dark, and stand great heat.	
	Clays which have been transported by glacial action bodily.	Leached	Whitish clays, comparatively free from carbonate of lime. Make excellent common brick, or coarse red pottery. Sometimes melt.	
		Common	Red, blue, or yellow clays, full of all kinds of debris. Boulder fragments, limestone, wood, are often found. Clays are too irregular to be of much value for practical use.	
	Clays which have been transported by winds.	Rock dust silts.	May be of various colors, they are usually quite siliceous and very fine grained. Loesses are common examples. May carry calcareous concretions. Due to their transportation by wind, they are often false bedded. Are used where better clays are not available for bricks.	

From this classification it may readily be noted that there are only two general or main types of clay, those which are primary as to origin, and, those which are secondary. The latter are not secondary as to value or importance but are so designated from the fact that they are in most cases far removed from their parent site of origin. Many of the clays in this group are known to have been transported not once but an unknown number of times; as a consequence wide alterations and changes of the clays took place, such as a reduction in size of the clay grains, chemical changes like the incorporation or removal of impurities, in the form of solids or solubles, oxidation, hydration, physical changes resulting from the intermixing or removal of non-plastic materials like sands, rock dust, organic matter and other detritus. Eventually most of them became hardened into shales or slate, the former being about midway between soft plastic clay and the hard weather-resistant slates. That is, the shales are semi-hard or stone like, but when crushed and properly mixed with water, they, for the most part, become plastic and workable and are used as the basic raw material for a great variety of wares commonly known as the heavy clay products.

While the Orton Classification is quite broad and lists most of the clays as to their general types and some of their uses, it does not stress the latter in detail; hence it is felt that some amplification is desirable, especially so in that many of those who may wish to make use of this report may not be sufficiently familiar with clays to know that some of them are used for more than one kind of ware, but in each case the clay will be named from the ware. For instance clay used for terra cotta is known as terra cotta clay; on the other hand, the same clay, if made into sewer pipe, would then be listed as sewer pipe clay, or possibly paving brick clay if so used. It is also desired to make clear that it is not an uncommon practice to blend two or more clays of different kinds of properties; the composite mixture may then be spoken of as a single clay. Stoneware is an example of this, particularly so in Saskatchewan where certain plastic and semi-sandy clays are mixed to produce the desired working and fired properties for that class of ware, or for yellow ware, art ware, face brick and sewer pipe. In each case the mixtures would generally be named from the particular ware.

In the following list and description of clays, more in particular of those which occur in Saskatchewan, an effort will be made not only to list all types but to elaborate quite freely on the use or uses for which each may be employed. It is not the desire by so doing to leave the reader with the thought or impression that clays which have been named from the products for which they are used would not in all cases prove complete within themselves for any one or all of those wares. In most cases adjustments have to be made to correct both the raw and burned properties, such as shrinkage, warpage, absorption, burning temperature, colour, resistance to impact, etc. The desired conditions are arrived at through the addition of either plastic, or short lean clays, grog, and other materials as may be necessary. In other words an unknown clay might by testing procedure prove to be a typical yellow ware clay and would be so reported, but before it might prove entirely satisfactory for that class of ware many further tests and work are usually necessary before it would be safe to enter upon the development of the deposit for industrial use.

TABLE NO. III

BURNED CLAY PRODUCTS

(Indicating usage of various types of clay)

General Types	Sub-types	Surface Finish	Methods of Manufacture	Miscellaneous Remarks
	Brick (Common) Solid and hollow	Sand Plain Clinkers	Soft Mud Hand molded Machine " Stiff mud. Dry Pressed	The better grades and clinker brick of this type are frequently used as face brick for architectural effects in many expensive homes and public buildings. Hard burned for sewers.
	Brick (Face) Solid and with holes	Smooth. Rough Textured, Glazed Enameled Stained	Soft Mud Stiff Mud Dry pressed Repressed	There are a great number of kinds of rough textured finishes.
	Brick (Enameled)	Bright, Semi-glossy, Matt, Dull. Many colours and shades	Dry Pressed Stiff Mud Repressed	Used where light and sanitation are desirable as well as other places.
Structural (Heavy clay . Products) Made from natural red and buff burning clays and shales. Also the buff burning plastic semi-fire clays	Building Tile and Fire proofing	Smooth Scratched Glazed Enameled	Stiff Mud	Made as Load bearing, Non-load bearing. Face, plain, glazed and backing up.
	Terra Cotta	Unglazed Glazed Enameled Slip coated. Rough finish.	Hand Molded Pressed Stiff Mud Machine Made	Used for face work. Ornamental and decorative.
	Roofing Tile	Smooth Unglazed Glazed Slip Coated Bright Matt Dull	Hand Molded Machine-Pressed, Stiff Mud by auger or rolls	The usual types are, flat shingle, interlocking and Spanish roll tile. Many special shapes are necessary.
	Quarry Tile	Smooth Unglazed Many shades	Hand Molded Dry Pressed Stiff Mud by auger. Repressed.	They are usually one inch thick and of variable sizes. Red most common, Used for walks, floors, roof gardens, etc. Must have low absorption.
	Flue Linings	Plain Usually without glaze	Stiff Mud	Used for lining chimneys and other like purposes.
Miscellaneous Structural Wares.	Wall Tile	Glazed. In tints or colours. Body usually white or light.	Most all are dry pressed	The body is usually a prepared whiteware, often including talc. Numerous shapes are required.
	Fire place Tile	Unglazed Glazed Smooth and rough textured. All colours.	Hand molded Dry Pressed Stiff Mud Machine made	Made from natural red and buff burning clays. Also as prepared white ware bodies.

TABLE NO. III—*Continued*

BURNED CLAY PRODUCTS

(Indicating usage of various types of clay)

General Types	Sub-types	Surface Finish	Methods of Manufacture	Miscellaneous Remarks
Miscellaneous Heavy clay Products Made from clays, shales, semi-fireclay and high grade fireclays.	Sewer Pipe Fittings Wall Coping	Salt Glazed Prepared glazes in a few cases.	Stiff Mud	The clays most used are the plastic semi-fireclays, the more refractory shales, and certain Sask. ball clays
	Conduits	Salt Glazed	Stiff Mud	The semi-refractory fire clays, shales and some clays. Uses, for under ground for carrying telephone and other wiring, cables, air lines, etc.
	Drain or Land Tile	Plain Unglazed	Stiff Mud	Plastic red burning clays and shales are used mostly. They must be absorbent.
	Paving Brick	Plain Flashed Wire cut Rough	Stiff Mud Wire cut Some re-pressed.	The shales and plastic semi-fireclays most widely used. Must be dense and tough, low absorption. Seconds frequently used for buildings.
	Refractories Fire brick Glass pots Tank blocks Crucibles Shapes Stove linings. Insulation brick, etc.	Plain Unglazed	Soft mud Hand and machine molded. Stiff mud. Repressed Dry pressed Casting Jiggering	All grades of fire clay are used plus other aluminous minerals like bauxite, diaspore, etc. Many types of clay refractories are required.

TABLE NO. III—*Continued*

BURNED CLAY PRODUCTS

(Indicating usage of various types of clay)

General Types	Sub-types	Surface Finish	Methods of Manufacture	Miscellaneous Remarks
	Red Ware (Flower Pots)	Plain Slip coated Glazed	Jiggered. Cast. Flower pot. Machine Made Seldom hand turned.	Mostly made from the plastic recent clays, or soft shales. Other than when glazed they are quite porous. Clays are at times washed. Often only pugged.
	(Kitchen ware)	Plain glazed Engobed and glazed. Banding colours	Jiggered. Cast. Pressed.	This class of ware has largely been replaced by yellow ware, stoneware, and cream coloured whiteware. The clays are washed and screened.
	(Art Ware & Novelties)	Plain Unglazed Slip coated Engobed Glazed Painted	Hand turned. Cast. Jiggered. Dry Pressed. Hand Pressed.	The red burning plastic clays are most used. Both high and low grades are usually washed and screened.
	Yellow Ware (kitchen ware)	Plain glazed Engobed and glazed or enameled. Banding colours	Jiggered. Cast. Pressed.	Mostly made from the plastic semi-refractory clays of the stoneware type. Of medium low absorption. Clays are washed and screened.
Pottery Other than Whiteware	(Art Ware & Novelties)	Plain and colour glazed. Enamels Engobes under glaze. Hand decorated.	Hand turned. Jiggered. Cast. Dry pressed. Hand pressed.	Same clays and preparation as for the kitchen ware.
	Stoneware (kitchen ware) all kinds. Crocks, Jugs, Water coolers, etc.	Glaze Plain Opaque or colours Banding	Same as for yellow ware.	In general the same clays are used as for yellow ware, but they are fired to much higher temperatures. The absorption is in most cases very low, even none at all. Body colour buff to stoneware grey.
	Chemical Stoneware Used for Acid containers. Acid pumps. Acid towers. etc.	Salt glazed, and unglazed Stoneware glaze in some cases, if so then single fired with the body. Glaze is not refractory like that on chemical porcelain	Jiggered. Hand made. Pressed. Cast. By auger.	The better grades of stoneware clays are used, carefully washed, feldspar and other fluxes sometimes added as well as flint, grog, and at times other clays. The body is usually stoneware grey in shade, non translucent, absorption very low or nil. Body single fired at approximately cone 8
	Art Ware	Unglazed Salt glazed Plain & colour glazed. Slips Engobes. Hand Decorated	Same as for art yellow ware.	Same as above re: kitchen ware. Some of the very finest art ware is produced as stoneware.

TABLE NO. III—*Continued*

BURNED CLAY PRODUCTS

(Indicating usage of various types of clay)

General Types	Sub-types	Surface Finish	Methods of Manufacture	Miscellaneous Remarks
Pottery (Whitewares) Not made from natural clays alone. Instead, china clays, ball clays, potter's flint, feldspar, or other fluxing agents are all used in the body composition.	**Earthenware** (Table and kitchen ware)	Clear and coloured glazes Over glaze by transfer printing. Very little under glaze decoration used.	Jiggered. Cast. Pressed. Automatic machines.	This ware is of heavy cross section. Body colour less important than better grade wares. Medium fire for bisque, glost fire much lower, is now translucent, cutlery marks quite easily.
	Semi-Vitreous China (Dinner ware) "Semiporcelains" of the United States	Medium hard Transparent Clearglaze and generally over glazed by transfer printing. Some gold used, especially liquid gold.	Same as for earthenware	In general this ware has a much lower absorption than regular earthenware, little if any translucency. Body white, cream or ivory. Extensively produced in the United States.
	China Ware (Dinner ware) American	The glaze is hard, and translucent. Over and Under glaze decorations. Transfer and hand work. Gold used.	Jiggered Cast Pressed	Absorption nil. Highly translucent, mechanical strength high. Bisque fire high, medium glost fire. Ware is of thin cross section.
	Hotel China (American)	Glazed with a hard transparent glaze, some tints used. Both under and over glaze decorations. Banding common.	Jiggered. Some casting. Pressing. Automatic machines.	Absorption nil or less than 0.3%. Medium translucency in the lighter weights. Body white or light coloured. Is very resistant to mechanical shock. Largely used by hotels, cafes, on dining cars, and a light weight type for home use. High bisque fire. Medium high glost fire.
	Porcelain (Dinner ware)	Glaze is very hard, clear and transparent. Under glaze much used, colours of same limited. Over glaze and gold used.	Jiggered Cast Pressing	Absorption nil. High translucency. Low temperature bisque fire where both body and glaze are fired to a very high temperature, usually cone 14. Only limited amount made in America.
	Chemical Porcelain (Laboratory ware)	Glazed and unglazed. The glaze is translucent, very hard & capable of resisting high temperatures.	Same as for porcelain	This ware is specially made to be highly resistant to acids and thermal shock. For use in the chemical industry and laboratories. Body white or light cream. Low fire bisque then body and glaze fired very high, cone 16 or better.

TABLE NO. III—*Continued*

BURNED CLAY PRODUCTS

(Indicating usage of various types of clay)

General Types	Sub-types	Surface Finish	Methods of Manufacture	Miscellaneous Remarks
Sanitary Ware	Bath tubs Wash bowls Closet bowls Tanks	Slip or engobe coated plus a transparent glaze. Also, tin and other opaque enamels are used. They may be white or of pastel shades. Glaze must be hard to resist the abrasion of scouring powders.	Casting widely used. Pressing. Over-casting Drain-casting.	Formerly made from the semi-plastic fire clays blended with grog, cream or buff when burned, also somewhat porous. The ware was engobed and glazed on all exposed surfaces. At present whiteware bodies are largely used and need not be engobed but may be covered by an opaque enamel. These bodies are semi-vitrified or vitrified. Usually two burns, i.e. bisque and glaze.
Electrical Insulators. Made from prepared bodies of the high fire porcelain type.	**Low Tension** for house wiring insulation such as; knobs, buttons, tubes, cleats. For electrical equipment, stove & switch parts. Telephone insulators.	Unglazed & glazed.	Dry pressed Plastic pressed. Auger insulating machines. Heading machines.	Body is usually well vitrified, need not be white but usually of a light shade. Very low absorption if not glazed. Draining common practice. Stoneware clays have at times been employed.
	High Tension Power line insulators, and for scores of other uses where high voltages are used.	Unglazed. Glazed. Transparent and dark colours. Fusible slip clays used at times for the glaze. Must be hard and resistant.	Jiggered Dry pressed Turned from blanks. Numerous other methods.	The body for this ware is of light shade. Very highly vitrified and must be free of flaws or cracks. Absorption nil. In most cases single fired to cones 10-14 and higher in some cases. Draining of the body is common practice. Stoneware insulators of this type are not common in America.
Burned Thermal Insulation Products	**Refractory** Standard fire brick size. A few shapes.	Unglazed	Dry pressed Stiff Mud by auger. Soft mud. Slop molded. Some casting. Bloating.	The most common of these are of the refractory type, used to reduce heat losses from kilns, furnaces, boiler settings, metallurgical furnaces, and many other places where high temperatures are employed. They are of low strength and resistance to abrasion. Are light in weight and mostly made from the plastic fire clays plus a combustible like coal, saw dust, weed seeds, straw, peat etc. Others by adding diatomaceous earth, volcanic ash or other light weight silicates, also through the use of gas forming materials. Improvements are continually being made.
	Structural Backing up hollow tile and shapes. Partition tile and other fire proofing. Need not be highly refactory. Clays, shales and semi-fireclays used	Unglazed	Stiff Mud by auger.	

TYPES OF CLAYS AND THEIR USES

Residual (Primary) Clays

There are two main types of primary clays, those which have been formed through the decay and alteration of parent rocks which were free, or nearly so, of iron or other colouring minerals and for that reason are not only white in their raw state but when burned as well, and those which had as their original source such rocks as basalt, schists, some granite and others which contained iron. In the raw unburned state the latter are variable as to shade or colour, usually yellow, red or even purplish, depending upon the amount of iron present and the degree of its oxidation plus the density of the mass. These clays quite naturally do not burn white but develop creams, buffs, and, more generally, all shades of red.

As to the distribution or form of a residual clay deposit, it will be found that they correspond to that of the underlying parent rock; if it was in the form of a dyke or vein like feldspar, then the clay deposit would be narrow, and variable as to width; the length on the other hand may be very great. In case the source rock was regional, that is horizontal and extending over a wide area of the country, then the clay beds would be in the form of a mantle covering a more or less extensive area, the depth varying with the degree of alteration, and in some cases thinned due to subsequent erosion following formation. While there are other cases of residual clay deposits, such as those from limestone, they are not likely to be found in Saskatchewan, and for that reason details regarding their formation will be omitted.

USES OF WHITE OR LIGHT BURNING RESIDUAL CLAYS

The white or light burning clays of this type, usually known as kaolins, or in some instances, as china clays, are seldom sufficiently pure to be used direct from the deposit; they first have to pass through a washing and refining process to remove the quartz and mica which have remained unaltered from the original granite or other source rock, the amount of quartz-mica wastage at times being considerably in excess of fifty percent. The freed and recovered clay portion is dried, often crushed, even air floated, and then bagged before it is ready for market. When thus prepared, it finds a wide use as one of the constituents in most whiteware bodies such as earthenware, semi-vitreous china, porcelain, wall and floor tile, and extensively as a filler in the manufacture of paper. While there are many other products in which kaolins are used, the amount employed is minor to that consumed by those listed.

One known occurrence of primary kaolin in Saskatchewan is that which occurs in the kaolinized sandy beds of the Whitemuds in the central south ,and south western part of the province. In addition to the kaolin in the sandy Whitemud beds in southern Saskatchewan, there are similar occurrences on the south shore of Pipestone Lake, east of Lac la Ronge. Both occurrences are more fully covered elsewhere in the report.

While there may be deposits of primary residual kaolin in the northern part of the province, it is quite unlikely that such is the case, because even in the event of kaolin having been formed in the area, it would have been during pre-glacial times, therefore as a result of the great planing action of the moving ice there would be little likelihood of any soft kaolinized rock remaining in place following the retreat of the glaciers. There are two possible cases where the kaolin might have escaped the action of the ice movement. The one most unlikely would be that where the early surface alterations had proceeded to depths below those reached during the glacial period, the other case would be where the kaolinization had been endomorphic, that is from deep seated sources upward as was the case at Cornwall, England, near Spokane, Washington, and other isolated localities as mentioned by Wilson (27).

USES OF DARK BURNING RESIDUAL CLAYS

None of this type resulting from the alteration of basalt rock is known to occur in Saskatchewan, but there are however, some bentonites and bentonitic clays which have been transformed from volcanic ash that are in place with the ash. Instances of these are the deposits a mile east of St. Victor, in the ash beds on Swift Current Creek near Duncairn, also on the NW. of 11-31-1w3, west of Rockglen, and at other points. In each case these clays and bentonites have developed dark shades of red when burned in the range of cone 02 and fuse into dark brown to black slags and glasses in the general range of cone 10. It is very doubtful if any of these can be used alone for clay products on account of their abnormal degrees of shrinkage both in drying and burning. They offer some promise as red burning slip clays, but the demand for this purpose is for the most part very limited or nil. Their greatest interest is in the direction of their use as plasticizers and bonding agents to other less plastic clays, or, to blend with others where it may be desirable to improve their burned shades of red.

Secondary Clays

SECONDARY KAOLINS

As to general appearance there is little if any difference between these and the primary kaolins. They are both, for the most part, white or light in shade, and therefore a careful examination is usually necessary to classify them. The secondary kaolin which will have been washed or transported by water one or more times from its original bed will show certain alterations. In most cases the clay mass will appear to be of a fine texture. The quartz and mica masses will have been broken down and may occur as individual grains and flecks, and will also be more uniformly distributed throughout the mass, and under the microscope, in case the distance of transportation has been great, many of the quartz grains will have become water worn and more or less rounded through the forces of abrasion, whereas in a primary kaolin they are sharp and angular.

Moving waters or streams were responsible for the transportation of the secondary kaolins and other clays, hence just so long as the current or velocity was sufficient to hold the sediments in suspension, they would be carried along until the stream emptied into a bay, a lake, or other quiet body of water. The velocity would then be gradually reduced, accompanied by a settling out of the larger masses of clay grains, quartz, mica, etc., and lastly far out from shore in the more quiet zones the finer sizes would be deposited. There are many evidences that nature has never been at rest; that there is an eternal cycle of mountain-building and erosional movement of the material in the earth's crust, which accounts for the variety of stages of metamorphism of once-igneous rock into the types of soil, clay, shale, or sedimentary rock which now exist. In ancient geological time the area comprising southern Saskatchewan was part of a sea or ocean bottom upon which were deposited the sands, silts, or clays from rivers in the dry-land area of that time. This under-water deposition continued until natural movement of the earth's crust raised these deposits above the sea, and they became new land areas, subject once more to the erosional forces of wind and rain. In some cases there is evidence that nature repeated the changes or conditions not once or twice but many times, the character, purity and type of the clay having been altered with each cycle. In the case of material having been moved once or possibly twice there would be high grade kaolins, while in other cases the clays would be of the lower grades, the degree varying most likely with the number of times they were exposed to contamination during periods of erosion and resedimentation. Had it not been for this natural lowering of the grade or quality of clays, it would now be impossible to have or produce all of the highly essential clay wares of the present time; as an example, building bricks are made from clays which are far removed from the kaolins in the matter of burning temperature, burned colour, and various other desirable and necessary properties. Kaolins are highly refractory and cannot within the limits of any commercially economical temperatures be so burned that they could be employed for structural building brick. The brick clays, on the other hand, in being moved from place to place gathered up and became intermixed with other minerals and detritus such as various forms of iron, silica and silicates, basic fluxes, and at times soluble salts, etc., with the result that in most cases they need only be burned to low or moderate heats in order to produce hard durable wares of good colours, usually red.

Owing to the condition under which the secondary kaolins and clays were deposited, they occur as beds from a few feet up to many feet in thickness, and usually extend over very wide areas laterally, miles in many instances, as in the case of the Whitemud beds in southern Saskatchewan. In further reference to the secondary kaolins, up to the present there is only one known deposit in the province. This deposit was discovered by the writer in 1921 on the south shore of Pipestone Lake. A long narrow lake skirts the foot of the north slope of the Bear Hills and carries the waters eastward from Wapawekka Lake. While the kaolin deposit was revisited in 1945 for the collection of preliminary samples, the deposit has not been prospected as to its area and possibilities.

These clays must be washed and refined before they can be used either in their raw form as fillers for paper, paints, etc., or when burned with other materials for the production of the several grades of whiteware. The same would be true in most cases where they may be of interest for certain refractories.

The properties usually demanded of a clay by the paper industry is whiteness, the absence of grit, the clay to be very fine grained, one that will disintegrate easily in water, slow to settle, and one that gives a good retention in the paper. It is general for the paper manufacturers to make their own tests, but this does not mean that preliminary advance laboratory tests should not be made prior to the submitting of samples for their observation.

In those cases where the interest in kaolin concerns its use in the whiteware industries, then the unburned and burned properties are both determined, not only those of the kaolin

alone but when used as one of the essential ingredients in a standard whiteware body. As the general uses of both primary and secondary kaolin are practically the same, then the following discussion of their more important physical properties may be considered as applying to both types.

Kaolins are not all alike in many respects; some are non-plastic, others semi-plastic, and a lesser number are plastic. There are some of each group which burn pure white or nearly so, and others which are a little off shade but are useful in certain wares. A chemical analysis of each sample may prove helpful in selecting those which can be expected to burn white, as it is usually those with less than one per cent. of iron or titanium which do so. If much in excess of that figure, then it is not possible to draw a definite conclusion as to the burned shade in that in some cases a sample with twice as much iron present to that of some other sample may burn to the best white. It would seem that the presence of certain other impurities, possibly lime, may have a fading or bleaching effect on the iron, thereby neutralizing its colouring effect. An actual burning test is necessary in all cases.

In addition to the determination of the burned shade or whiteness of kaolins, there are other important properties which must be determined in an examination and testing of same. For instance, it is desirable to measure the grain sizes and to know the percentage of each in that those kaolins composed of the higher percentages of the finer particles are the more desirable; small minute grains react more easily with the other body ingredients during the vitrification stages.

For certain wares and shapes made from bodies containing kaolin it is desirable and often necessary to resort to slip casting in place of pressing or jiggering. In such cases it is found that in the selection of the basic raw materials for the casting body, certain kaolins may prove satisfactory while others may not, the difference being due in a large measure to the pH (the degree of alkalinity or acidity) of each sample. In those cases where a kaolin proves unfavourable it is usual to discard it or to introduce a second or even a third kaolin with different pH values until a proper balance has been reached. It is therefore essential in the testing of kaolins to determine and report their pH.

Other properties measured are the raw and burned strengths, drying and firing shrinkages, shrinkage and pore water, absorption and P.C.E. (Pyrometric Cone Equivalent—softening point as measured by cones).

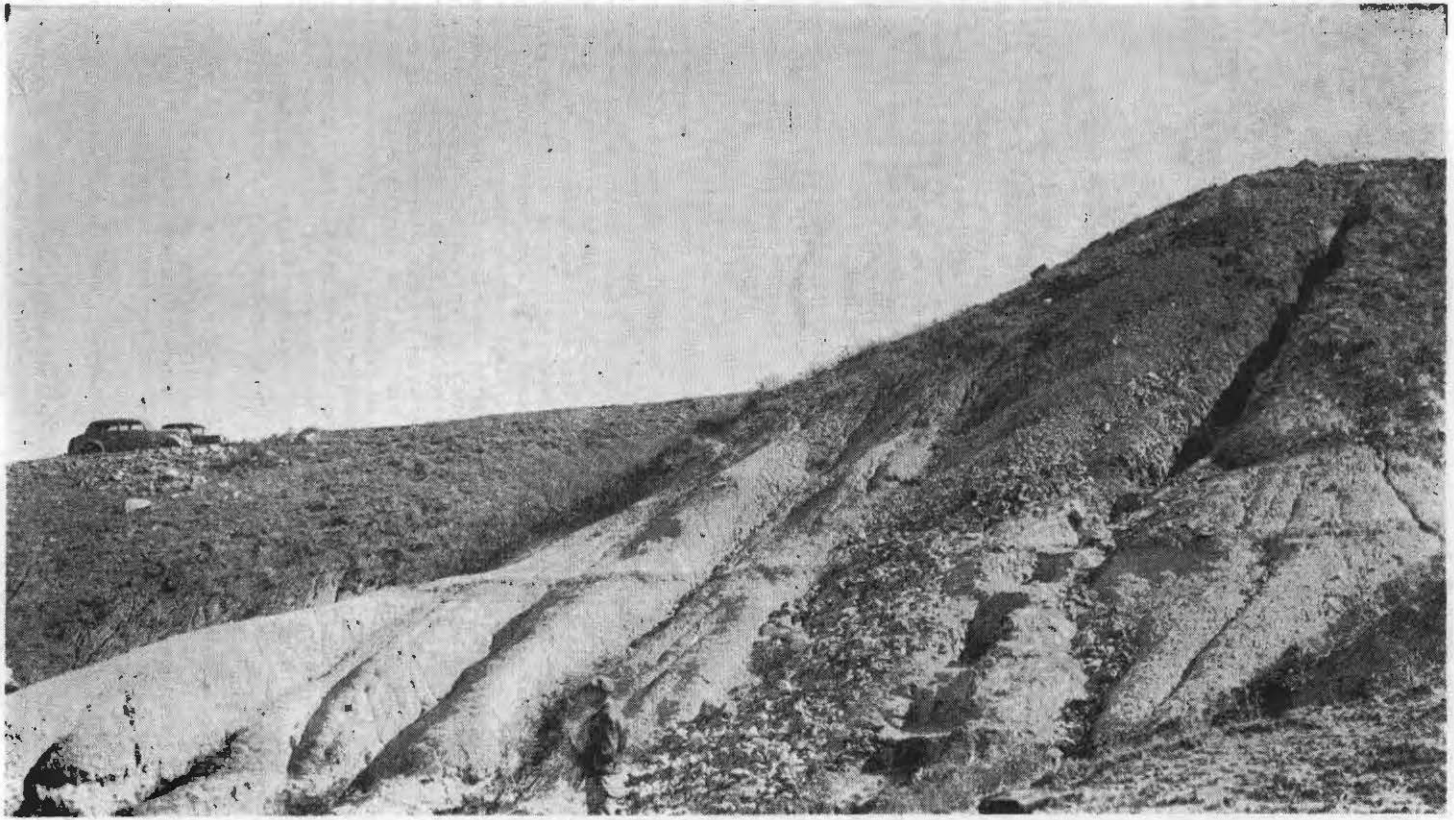
BALL CLAYS

In general the ball clays are not so pure as the kaolins, and are in most cases of finer grain size, more plastic, not quite so refractory, and do not burn to the same degrees of whiteness as the better grade kaolins. There are exceptions to this, and especially so in the case of certain Saskatchewan ball clays which in whiteness, when burned, equal that of the very best white burning kaolins. While there are some ball clays which are white in their raw state, the greater majority are of tints and shades which range from light cream and pink to purple, chocolate and even black, plus others like buff, lead grey, blue, etc. All of the above are found in Saskatchewan. While ball clays are low in iron content, some of them contain sufficient when oxidized to be noticeable in the raw material, but for the most part the shades or colours which prevail are from organic sources, hence a natural dark coloured ball clay may when burned be of a white or lighter shade than one which occurs as a pink or yellowish shade in the deposit, since the organic matter burns out, whereas the iron does not.

Ball clays are used in practically all whiteware bodies and therefore must burn white or to very light shades, and they must be free of black or brownish speck-forming minerals. For this and other reasons some are now specially prepared for the markets by drying, pulverizing, and air floating. In other cases washing followed by magnetic separation is employed, whereas in the past all ball clays were marketed direct from the pit, except for a certain amount of air drying to reduce the moisture content. In general this may vary from sixteen per cent. in the light ball clays to twenty per cent. for the dark ones.

The advantages gained through the use of ball clays in the usual bodies are many; in the raw body they are necessary to the workability of same and to add to the dry strength, thereby reducing drying and handling losses prior to the bisque burn. In those cases where casting is employed, especially for sanitary and other large wares, ball clays are very important to the properties of the slip. While electrolytes are widely used in the preparation and control of casting slips in which ball clays are used, there are, however, instances where the desired properties are produced through a proper selection and combination of the clays such that the rate of casting, the set or drainage, the release, plastic strength and other properties, are all satisfactory without the use of electrolytes.

In the burned body, ball clay increases the strength and degree of vitrification due very largely to the fact that most clays of the ball clay type become dense and hard at temperatures far below the kaolins, either primary or secondary, and thus tend to harden the body. There is, however, a wide difference in ball clays as to their rate and temperature of vitrification. Some, including a number of the English clays, vitrify very early and then do not change or overfire until very high temperatures are reached. There are others which close up, that is, vitrify very



Trench Sampling of Saskatchewan Ball Clays in the Flintoft area. Near the top the beds are of the Ravenscrag formation.

slowly. These remain open and quite porous until fairly high temperatures are reached. For this reason, in many cases, they are not as desirable as the first type. Both kinds, as well as those which are intermediate, occur in Saskatchewan.

The data and information usually required from the testing of a new or unknown sample of ball clays are: its rate of slaking, the per cent. of residue caught on screens up to three hundred mesh, the grain size, the pH, per cent. of water of plasticity, shrinkage and pore water, per cent. drying shrinkage, the transverse strength measured as the modulus of rupture, the viscosity of its slip alone and with electrolytes, the rate of settle following blunging, and a chemical analysis.

The burned properties of most interest are: its rate of oxidation, the percentage shrinkage, absorption and modulus of rupture at various temperatures, its vitrification behaviour (that is, early or late, fast or slow), its P.C.E. (softening point), its colour and freedom from specks. All tests should be in accordance with the standards of the American Ceramic Society and the A.S.T.M.

FIRECLAYS

Clays of this type are those which are capable of withstanding high temperatures, though that property alone is not a measure of the ultimate usefulness of any particular fire clay in that there are many service conditions where clays of low or moderate softening points (P.C.E.) are of more value and importance than those of the highest P.C.E. values. The chief differences in such cases are those of a physical nature rather than that of refractoriness. To clarify this point, there are cases where the temperatures which the ware must withstand may not be excessively high, while on the other hand the ware must resist the abrading action of the material being treated. For instance, in a cupola type of blast furnace the lump limestone, coke, and iron ore fed in at the top cause a severe wearing action on the fire brick lining of the furnace until the charge enters the melting zone near the bottom of the furnace; the upper portion of the cupola therefore requires a firebrick of considerable mechanical strength, while in the lower zone a high temperature resistant brick is required.

As shown in the Orton Classification of fire clays, there are two general types, those which are highly refractory and those only moderately refractory. Of the first type, a further division is possible, first: the non-plastic flint clays, and secondly: the plastic fire clays. There are several grades and kinds of each type; for instance flint clays are not all of the same degree of refractoriness or non-plasticity, while most all of them if finely ground and then tempered over a long period of time can be made slightly plastic. There are others, which might well be called semi-flint clays, that yield a fair degree of plasticity when treated in the same manner.

The chief value of flint fire clays in addition to their high degree of refractoriness is that of their non-plastic condition or property, in that they are, as a result, valuable as grog in place of burned dobies or other sources of shrinkage-reducing materials. While flint clays are and have been widely used in the production of high heat resisting refractories, some of the kaolins are now used for the same class of wares. There are no known occurrences of flint clays in Saskatchewan and the same may be said of Canada in so far as strictly high grade flint clays are concerned. The discovery of a deposit of same within a reasonable distance of shipping facilities would be of major importance. The world's known occurrences of flint clays are extremely few in relation to those of the plastic type of which there are more kinds and grades, some being highly refractory, others only moderately so, and still others which do not meet the requirements demanded for the lowest grade refractory. Further, there are fire clays of the siliceous type where the silica is greatly in excess of the clay portion; these are commonly known as sandy fire clays, and there are others; hence the term fire clay is used in a broader sense than to designate mere refractoriness. As an example, there are those clays known as plastic fire clays, which are employed for the manufacture of stoneware and sewer-pipe that are so low in the scale of refractoriness that they could not be used for that purpose at all, but they have some of the general properties of true fire clays and in many cases are found closely associated with them, especially as to their occurrence and geological age.

The definition for fire clay proposed by The Committee on Geological Survey of the American Ceramic Society (1) is as follows:

"A clay either of sedimentary or residual character which has a P.C.E. of not less than cone 19. It may vary in its plasticity or other physical properties; and while it often fires to a buff colour, it does not necessarily do so. It is recommended that clays with a P.C.E. from 19 to 26, inclusive, be called "low heat-duty fire clays" and that fire clays with a P.C.E. of cone 27 or higher be designated as "refractory".

The term "Nos. 1, 2, and 3, fire clays" as sometimes used do not always refer to the same degree of fusibility.

While some fire clays are found underlying coal beds, many show no association with coal; in fact, some clays underlying coal beds do not conform to the description given."

Of the many samples of clay taken from beneath the floor of coal mines in Saskatchewan, none by test have ever proven to be fire clay. There are, however, cases of refractory ball clays in the province which occur directly beneath thin lignite seams. In such cases there is

no evidence to support the theory that the lignite or coal was responsible for the purity of the clay beneath it. There are, on the other hand, reasons to assume that the clay when originally deposited was of the same degree of purity as that of the present time.

Among the more usual types of clays which fall under the common term fire clay are those known as bond clays, stoneware clays, sewer pipe clays, pot clays, sagger clays, wad clays, sanitary ware clays, terra-cotta clays, and others including pipe clay (sewer-pipe clay) crucible clays, the clays being named from the wares or purposes for which they are used.

Furthermore, large quantities of the lower grade plastic fire clays are used in the manufacture of face brick, fire proofing, paving brick, face and back-up hollow structural tile, glazed fire place tile, enamelled brick, quarry tile and other wares. It is therefore apparent that the fire clays from the most highly refractory ones to those of the lower grades are clays of very great industrial importance. There are no other types of clay which are or can be used for the production of such a wide variety of wares as those now manufactured from the various kinds and grades of fire clay. In this respect Saskatchewan is in a favourable position in that there are known occurrences of practically all kinds of useful fire clays in the province except those of the flint and highly aluminous types, the latter being clays where the alumina content is in excess of that of kaolinite or of the ratio of Al_2O_3 .2 SiO_2.

A classification of fire clays which divides them as to their resistance to heat as measured by the deformation temperatures of standard pyrometric cones is given below:

The No. 1 clays are those which soften and deform at or above cone 31 (1,685°C. or 3,065°F.), while those which deform at cone 26 (1,600°C. or 2,918°F.) to cone 31 are classed as No. 2 clays. The No. 3 clays are those softening below cone 26. Those clays which fall into this, the No. 3 class, are the ones of interest for their use in low grade refractories, face brick, sewer-pipe, stoneware, terra-cotta and other like wares. In some cases the No. 2 clays are blended with lower grade clays and are thus made useful for the same general purposes. Where the plastic fire clays are used for the making of fire brick and other refractory shapes, it would be quite unusual to find a clay that could be used alone. In most cases it is necessary to correct some of its raw and burned properties by the addition of grog, other fire clays, and in some cases through the use of refractory materials other than clay. Alterations to the parent clay are also made to bring them into the different desired conditions required by the processes of manufacture, such as the soft mud, stiff mud, and dry press processes for making brick.

Fire brick made from fire clays have been classified by the American Society of Testing Materials into five classes: (1) High heat duty clay fire brick, the softening point of which shall not be lower than that of standard cone 31. (2) Intermediate heat duty clay fire brick, the softening point of which shall not be lower than that of standard cone 28. (3) Moderate heat duty clay fire brick, the softening point of which shall not be lower than that of standard cone 26. (4) Low heat duty clay fire brick, the softening point of which shall not be lower than that of standard cone 19. (5) High heat duty siliceous clay fire brick containing 70% or more SiO_2, the softening point of which shall not be lower than that of cone 28 (about 1,630°C. or 2,975°F.).

In addition to obtaining of the P.C.E. values of fire clays and wares made from them, there are a large number of other tests which are necessary in most cases. A number of these tests have been made as standards by the A.S.T.M. Others are in the tentative stage and some are in common use for the information which they supply.

The first test or examination of an unknown clay suspected of being a fire clay is the determination of its P.C.E. value which places it in a grade as to temperature above which it would not be suitable. It does not reveal any of the working properties of the material nor its ability to carry a load while under heat in service, its shrinkage or expansion, its density or openness when properly burned, as well as many other properties which must be determined, depending in each case on the type of refractory which it may be desired to make from it.

The importance of research in the field of refractories is well recognized. This is evidenced by the large sums of money, the talent, and the well equipped laboratories that are now being used to improve the quality of the ware wherever possible, and to develop new lines and grades of refractories. This is necessary in that higher service temperatures are demanded, also better resistance by the refractories to slag action, spalling, load while under heat, and so forth, including the need for refractory insulation products. It is doubtful if there is any other branch of ceramics that is making greater strides in advancement than that of the refractory industry at the present time.

The production of refractories in Saskatchewan was started at Claybank in 1911, using fire clays which had been discovered in the nearby Dirt Hills. Since that early start the plant has developed into the largest clay products plant in the province. The kinds and grades of refractories now made are so varied that additional supplies and types of fire clay are brought to the plant by trucks from the Blue Hills, thirteen miles to the west, north-west of Claybank.

There are other clays in the southern part of the province which meet the requirements of fire clays in so far as their P.C.E. temperatures are concerned, the ball clays being examples of this, though as pointed out before, fusion point alone does not necessarily qualify a clay for the production of refractories.

Slump blocks of Whitemud clays south of Claybank, Sask.

There are also the kaolinized sandy clays of the province which in general qualify as refractories by the P.C.E. test, though in nearly every instance they are too low in silica to meet the standard requirements of a siliceous fire clay.

On the other hand, the percentage of silica present is a diluent of the clay portion and thereby, depending on the amount, tends to lower the P.C.E. value of the clay below that which it otherwise would be. The clay portion being kaolin will have a high fusion point, though this is variable, of course, with the purity of the sample in each case. It is therefore worthy of note that the kaolinized Saskatchewan sandy clays offer important possibilities as a source of kaolin for use in the production of kaolin refractories. To make this possible, it will be necessary to devise an economical method of separating the silica from the kaolin. The per cent. of yield of the latter must be such that its recovery would prove justifiable. In connection with the matter as a whole, it should be understood that due to the higher cost and other characteristics of kaolin refractories, they are only used for certain special conditions; therefore, the market for them is materially restricted in comparison with the regular fire clay refractories.

REFRACTORY BOND CLAYS

In general these are clays which are highly plastic, have high bonding powers for less plastic clays and non-plastics like flint clay, grog, graphite, and other materials. They must be refractory and for certain uses must have a long vitrification range before overfiring. Their firing shrinkage should be low.

Deposit at Twelvemile Lake, south of Maxtone.

Their greatest use is in connection with refractories, particularly those used for glass pots and other glass refractory wares, clay crucibles, graphite crucibles, retorts, especially those for zinc.

Naturally there is no single bond clay capable of meeting all conditions or proving satisfactory in all of the various wares; that is, the service conditions are quite varied and as a result it is the usual practice to blend two or more bond clays of opposite types, thus making it possible to develop and control mixtures of definite properties for each purpose.

Prior to the first world war, the most widely used bond clays in the United States were imported from Germany. Eventually, as the war continued and further supplies were not obtainable, a study was undertaken by the United States Bureau of Standards on a number of clays from various local deposits to learn if among them there were any which could he used to replace the imported German clays. The findings definitely proved that such was the case. The work was done under the supervision of A. V. Bleininger, Ceramic Chemist of the Bureau, and the results were published in 1920 as Technologic Paper No. 144 of the Bureau of Standards (4). By means of the data obtained, it was possible to present some rules as an aid in classification, tentatively at least, of clays of the bond type. The division or classification of such clays is based on their properties in the raw state and their behaviour during burning. In the first case those of a pore to shrinkage water ratio of 1 : 1 and which with sand in the ratio of 1 : 1 develop a raw modulus of rupture strength of 325 pounds per square inch or more, would qualify for Class A, and those with strengths between 225 and 325 pounds would take a Class B rating.

The principal burning data required is the overfiring temperature and the softening point of the clay, it being stated that for severe service, the bond clay should not become decidedly vesicular at a temperature below 1,425°C. (approximately cone 15+), and should not have a P.C.E. lower than cone 31, though for certain plastic clays largely used in the making of graphite crucibles, it is mentioned that they should not overfire much below 1,400°C. and should have a cone 30 P.C.E. Clays below either of these requirements should not be considered as being high-grade bond clays.

It is specifically stated that more weight should be placed on the overfiring temperature than on the softening point. In addition to the ultimate temperature of overfiring, the rate at which it occurs, and the amount, are both important. In addition, there are three types or classes of clays indicated by the burning temperatures at which they become dense in relation to their overfiring temperature. Briefly, they are: first, those clays which become dense quite early, about 1,150°C. (Cone 3) and show no overfiring at 1,400°C. (Cone 14+) (this type, if the other properties are satisfactory, is particularly suitable for graphite crucibles used in brass melting); second, those clays becoming dense in the general range of 1,275°C. (Cone 10 to 11) and not overfiring at 1,400°C. or higher (clays in this group or class are suitable for crucibles used in steel melting. Those which do not overfire below 1,425°C. are useful for glass refractories); and third, a class which covers those clays possessed of good strength and which do not vitrify early, not becoming dense before 1,425°C. or higher (clays in this class which overfire at about 1,450°C. are particularly useful for the glass industry). The unsuitable clays are mentioned as being those which become dense anywhere between 1,150°C. and 1,300°C. (Approximately cone 3 to cone 12) if possessed of a poor range or a very short one before overfiring is reached.

While no special study has been made of the Saskatchewan refractory clays regarding their use as bond clays, from past tests and work on the ball clays of the province, there have been a considerable number which possess properties proving them to be of interest as bond clays. They are further discussed under ball clay.

SAGGER CLAYS

There are certain wares like pottery which cannot be open-set in the kilns for burning; that is, they should not be subjected to flame, smoke, or fly ash. Further, they are of thin cross section and for that reason they would crush or break if placed very deeply, one on another. It is, therefore, necessary to protect and carry the ware in such a manner that it may be burned under the most favourable conditions. In most instances, this is made possible through the use of saggers of suitable size and depth for the various pieces of ware. Saggers are open top boxes made of fire clay, though at present other materials are now finding a limited use for saggers. The saggers are filled with the ware and placed in the kiln one above the other in stacks or "bungs" as they are called by the potter. The lowest sagger, that is, the one on the floor, has to carry the weight of all the saggers above it and their load of ware. Each sagger in ascending order has a little less load to carry until the top one is reached. It then has only the ware in it and a covering tile or empty sagger to support.

In addition to the load which saggers have to stand up under during the burns, they are subject to breakage while being filled with the ware, while being transported into and out of the kiln each burn, as well as strains which arise from too rapid heating or cooling which may cause cracks or even spalling. It is therefore apparent that the choice of clays for saggers is one which requires careful attention. In general, sagger clays are not unlike bond clays and are either a grade of ball clay or plastic fire clay. While it is desired to have a clay which is free

of iron and other impurities, these are at times higher than in the case of clays used for whitewares. A clay or mixture of clays to be suitable for saggers should be of good plasticity, fairly high in bonding power, of low and stable burning shrinkage, and should have little or no deformation while under load and temperature. Its co-efficient of expansion and contraction should be low.

With the ever-increasing use of car tunnel kilns where open setting is common, saggers are gradually being replaced by special shaped refractory supports and tile. This, however, may not greatly reduce the use of sagger clays in that where the supports and tile are made of fire clay they must have the same general properties as those required of saggers. Therefore, the same clays may be used.

Among the Saskatchewan ball and allied clays there are those which are distinctly of the sagger type, as will be shown in Chapter 4 where the various types of the Saskatchewan clays are discussed in detail.

STONEWARE CLAYS

Clays of this type are sedimentary as to origin, and for the most part are those clays known as the low grade plastic fire clays. They should have good plasticity and strength and when burned should become well vitrified, in some cases to very low degrees of porosity. The usual desired burning range for these clays is from temperatures corresponding to cones 4 to 7 or 8, so that slip clays and unfritted leadless glazes may be used single fire. A total shrinkage of 12 per cent. is a fair average, though it is more important that there be a freedom from warpage or twisting while under fire. The burned colour may be light yellow to buff when soft burned and stoneware grey when well vitrified. The same clays are used for the production of yellow ware, the chief difference being that they are then fired at lower temperatures, and the ware is usually bisque burned before glazing; in other words, two firings are made.

Saskatchewan stoneware clays have been used industrially for many years, the supply coming from the Whitemud beds in the general vicinity of Eastend. Further east in the province, there are other deposits of stoneware clays which occur in the Willowbunch beds, of later geological age than the true Whitemuds. In both cases the clays tend to mature and bluestone at lower temperatures than are common to the same types of clay in the United States, where slip, raw leadless, and salt glazes are commonly used for economical reasons. The local clays, when so desired, have their working and burning properties adjusted by the addition of a more refractory and sandy clay which occurs in the same deposits, usually right below the stoneware clay.

SEWER-PIPE CLAY

The American Ceramic Society committee on geological survey (1) in their recommended definitions for clays make the following comment regarding the use of the name, Sewer Pipe Clay: "This term, which is practically obsolete, is sometimes applied to a clay used for the manufacture of sewer pipe. It is as indefinite as terra-cotta clay." In this connection, it may be said that while there is no single clay used for the purpose, those that are employed must possess certain fairly definite properties. It is therefore generally necessary to blend two or more clays in order to develop a body having the desired properties, and in such cases it would be quite natural to speak of same as a sewer pipe clay and less often would it be termed a sewer pipe body or mix. It is quite true that there are pipe made from a single clay, and, in some cases from a refractory shale. Even in these instances, it is most likely, if the deposits were carefully examined, there would be found different layers or beds of clay, some portions being more plastic or sandy than others, and all being loaded out together as a common mixture and referred to as sewer pipe clay.

The clays most widely used for the manufacture of sewer pipe and their kindred wares are the lower grade plastic refractory clays; in many cases those known as stoneware clays. As stated before, some shales are used, and in the case of Saskatchewan, not only the stoneware clays are drawn upon but the highly plastic ball clays as well, plus some of the sandy clays which fortunately occur closely associated with the stoneware and ball clays.

The main raw and burned properties which a clay or blend of clays should have for the manufacture of sewer pipe are: a fair degree of plasticity, tough but not sticky while in the plastic condition, low drying shrinkage (this is often controlled through the use of grog or siliceous clays), a composition and temperature of burning such that the pipe may take a proper salt-glaze. Iron in the clay, if not in granular form, is desirable in that it is necessary to produce the desired dark brown colour of the glaze. Soluble salts which produce dryer scum on the ware should not be present, though small amounts may be counteracted through the use of barium carbonate. The scum when present on the surface of the ware tends to prevent the salt fumes from coming in contact with the silica and alumina in the pipe and thereby prevents the formation of the glaze. It goes without saying that the clay or mixture of them should contain sufficient fluxing impurities to produce a dense body of low absorption and of a high burned strength. While some sewer pipe are fired as low as cone 2, in the majority of cases the more desirable clays are those which require somewhat higher temperatures, preferably

cone 4 to cone 8, where the decomposition of the salt and the reaction of the released sodium fumes in forming the glazes are better. Temperature alone will not suffice; the composition of the body is very important, as proven by Barringer (2) who conducted an extended investigation by means of chemical analysis, of a high grade sewer pipe clay then in use, and that of the salt-glaze formed on the ware. He prepared a wide range of bodies from low to very high silica content. The trials of same were burned in a kiln of sewer pipe and thus received the same glaze treatment as the pipe. Briefly his findings were: 1st: That a clay may be either too aluminous or too siliceous to be successfully salt glazed. 2nd: Clays containing alumina and silica between the molecular ratios of

1.0 alumina to 4.6 of silica
1.0 alumina to 12.5 of silica

are capable of receiving a salt glaze under proper conditions. Ratios above or below the above were unsuitable. 3rd: While the above set the limits, for practical reasons in forming the ware the higher ratios of even 1 to 9, or 1 to 10, could not be used. 4th: The grain sizes of the free silica added made little difference in the brightness, smoothness, and finish of the glaze. 5th: As regards colour, the finer sizes of the sand produced the lighter colour. This had also been found to be true in plant practice where the trials were burned.

That there are suitable clays in the province for the manufacture of sewer pipe and kindred wares need not be questioned in that they have been successfully and continuously used for their production at Medicine Hat, Alberta, during the past thirty-five years.

SHALES

Shales at one period of their formation were in the form of clay sediments deposited on the floor of past oceans, lakes and bays, and in many cases they were later covered to great depths by other materials like silts, sands and in many cases more clay, until hundreds, even thousands of feet were built up; the weight thus imposed on the clay sediments first deposited was sufficient to cause a consolidation or hardening of them until they took on the general properties of stone, and thus, while of the same composition, were no longer soft plastic clays. In other cases, even though the load or weight was not excessive, the hardening resulted from the presence of certain forms of cementing materials deposited with the clay as impurities, such as certain forms of iron, calcareous materials, silica gel, colloidal matter and even organic substances. There are wide extremes of hardness in shales; some are quite soft, not unlike dry clays, while others are very hard and difficult to break down and may be thought of as fossilized clays. None of them, other than slate, are wholly lacking in plasticity if finely ground and well tempered with water. The softer, or in some cases the geologically younger shales regain their plasticity quite easily and are as workable as the more recent plastic clays.

Most shale beds or deposits have marked evidence of stratification, though in some this may not be easily recognizable except by an examination of the deposit as a whole. Some of the individual beds of same may be nodular, others massive, and some of a blocky structure. In addition to the hardness of shales and their type of bedding, there are wide variations as to composition; some are sandy, some silty, others in clay substance, some are ferruginous or calcareous, and as well there are those containing large or small amounts of organic matter in one form or another. Among the more common impurities are iron, in various forms, and calcium, often as the sulphate or carbonate. There is also a wide variation of colour or shades of shales, including yellows, reds, blue, grey, black, green and others. In some cases the colour results from the presence of an impurity; for instance, carbon may produce shades of purple, brown, chocolate and even black, depending on the type and amount of carbon present. Iron is a common source of pink, yellow, rusty, red, chocolate, etc., colours, the shade imparted to the shale or clay being more from the degree of the oxidation of the iron than from the amount of it present. When iron is in its reduced form as ferrous iron, the shale will be blue, grey or greenish. It is not uncommon to find the exposed shale at an outcrop to be yellow or light in shade, then in the event the deposit is worked, at greater depth or distances back from the face, to find the colour changed to lead grey, blue, or green, which indicates that the iron was well oxidized at the surface, followed by little or no oxidation deeper under cover.

Shales usually extend over large areas, many miles in some cases. In this respect they differ from the recent clay deposits which usually occur over more limited areas and are not regional. Some shale deposits contain intrusive bands or strata of sandstone, calcareous siltstone, concretions of clay-ironstone, coal, lignite and other materials. Deposits containing any of them in excess are avoided by the ceramist.

Shales are widely used for the manufacture of common and face brick, structural tile, quarry and roofing tile, paving brick, in some cases for sewer pipe, conduits and other wares of like nature. Manufacture is usually by the stiff mud process, though many bricks are made from shale by the dry press process.

Shales are common to many of the geological formations of the various periods from quite early time. Those shales which are found at or near the surface in Saskatchewan are in the Cretaceous and Tertiary, though shales have been encountered much lower down in some of the deep bore holes which have been drilled during the past.

The following, Table IV, revised from G.S.C. Memoir 176, p. 9 (7) indicates those formations in which shales occur in southern Saskatchewan.

TABLE OF FORMATION

Era	Period	Epoch	Formation		Thickness in feet (approx)	Kinds of material, possible uses for same. Comments.
CENOZOIC		Pleistocene			0–400	Boulder clay—lake clay, etc. Boulder and other glacial clays of the Province are of little interest for Ceramic uses, they carry detrimental lime pebbles. Lake clays in some cases are suitable for common brick and tile, drain tile, flower pots, etc.
		Erosional unconformity				
	TERTIARY	Miocene	Wood Mountain		50	Gravels, some sand, quartzite pebbles unconsolidated and some cemented with calcium carbonate. Usual uses for sands and gravel. Pebbles by selection are of interest as ball mill pebbles.
		Oligocene	Cypress Hills		125	Gravels, sands, quartzite pebbles, volcanic ash. Pebbles are both unconsolidated and cemented, 1 to 6 inches in diameter. Of interest for use in ball mills. Volcanic ash has several uses.
		Eocene	Swift Current		50	Gravels, sands, conglomerates, etc. General interest same as for Wood Mountain and Cypress Hills formations.
		Erosional unconformity				
		Paleocene	Upper Ravenscrag		100–350	Sands, young shales, silty and sandy clays, clay ironstone bands, coal, volcanic ash, bentonitic clays, etc. The shade is buff to light grey. Some of the shales and clays offer interest for common brick and like wares; they will be buff in shade due to calcium carbonate in the raw material. The volcanic ash and bentonitic clay have industrial uses.
				Willowbunch	10–30	Highly plastic and sandy clays, semi-refractory. Nearly white, grey, dark brown etc. re colour. They are of interest for structural wares, yellowware, stoneware and certain low grade refractories. (There are two beds in some instances.)
					420	Sands, young shales, silty and sandy clays, coal, bentonite, etc. Of the same general shade as those above the Willowbunch. General uses for the clays and shales same as the same beds above the Willowbunch.

TABLE OF FORMATION—Continued

Era	Period	Epoch	Formation	Thickness in feet (approx.)	Kinds of material, possible uses for same. Comments.
MESOZOIC	CRETACEOUS	Upper	*Frenchman	20–190	Sands, young shales, silty and sandy clays, bentonitic clays, cross-bedded sand beds, large log-like sandstone concretions, ironstone concretions, etc. The general shade is grey. Possible uses of clays and shales, same as for Upper Ravenscrag.
				Erosional	unconformity
			†Battle	20–30	Non-refractory, greenish-grey, chocolate brown to nearly black, bentonitic clay, silts, shale and olive-green bentonite. The latter is of economic interest as are some of dark shales and clays mentioned elsewhere in the report.
			Whitemuds	12–75	Refractory and semi-refractory plastic and kaolinized sandy clays, white, purple, chocolate, black, light and dark grey. These are the highest grade clays in the province, buff, yellow, light and white burning. Useful for yellow-wares, stoneware, whitewares, sanitary ware, various grades of refractories, sewer pipe, fire proofing, etc.
			Eastend	20–100	Fine sands, coarse silts, fine sandstone, bentonitic shales, arenaceous shales. General shades are yellowish-green, lead grey and yellowish. Ironstone bands and sandstone concretions are fairly common. The shales are of doubtful value for ceramic use.
		Cretaceous	Bearpaw	700	Bentonitic shales, some zones of fine sands, coarse silts, bentonite, concretions of iron are common. Selenite and barite crystals, etc. scum-forming salts are in excess amounts. The shales are dark in shade, brownish and dark grey. They weather easily to a sticky clay. Due to their abnormal drying shrinkage and scum-forming salts they should be avoided for use in ceramics. Volcanic ash occurs in the Bearpaw beds near Waldeck; was used as a cleanser base for several years.

*—Formerly Lower Ravenscrag.
†—Formerly Zone 4 of the Whitemud.

TABLE OF FORMATION—Continued

Era	Period	Epoch	Formation	Thickness in feet (approx.)	Kinds of material, possible uses for same. Comments.
			Belly River	0–890	Fine grained sandstone, sandy shales, colloidal clays and shales, coal, bentonite, selenite crystals, ironstone and sandy concretions. The general shade is light, grey, yellowish, greenish etc. The chief uses of interest for the clays and shales are for structural wares, particularly by the dry press method. Drying shrinkage is high when used plastic. Certain beds of the Belly River have been worked for many years in Alberta for face and common brick. Mostly dry press. No use of them has been made in Saskatchewan.
			Lea Park	810–1,140	Shales, sandy shales, fine grained sand near the top. Irregular ironstone nodules. Only exposed on Battle and North Sask. rivers. The beds have not been exploited. Likely uses, building brick and other structural wares.
		Lower Cretaceous	Alberta	In Sask. 580- ?	Dark grey and black carbonaceous shales, iron bands and nuggets, bentonite sands. (The above is the upper part of the Ashville formation along the Etomami and Red Deer rivers, Bertwell to Erwood).
					Grey sands, shale, coal.
	Jurassic			0–440	Grey and variegated shales, some limestone.

3. The Clay Working Industry of Saskatchewan

GENERAL COMMENT

It was in the early days of the North West Territories, long before Saskatchewan had been made a province, that the local clays were first used for the making of bricks, though ages before that period the Indians of the plains made wide use of those same clays, using some of the highly coloured ones as war paints when the occasions arose, and for facial decorations during more peaceful times. In addition to those uses, other clays were made into many useful wares like food bowls, cooking pots and other shapes for carrying water, all of which were burned, as has been proven many times through the finding of, for the most part, broken shards of their articles. They have been found widely scattered from the far south to the woods areas in the north. There is no evidence to indicate that there was any particular clay or locality which the Indians used or preferred such that there might have been developed an industrial centre, to use a term of the present day. Indications are that when articles were needed, most any surface plastic clay was taken; it in turn was mixed with a liberal amount of sand to prevent the newly made ware from cracking during the drying stages. It would seem that little care or attention was given to burning the ware hard, and, in consequence it was soft and easily broken, hence the rarity of finding anything but shards.

The early whites did not concern themselves with the making of pottery; they needed buildings, and having come from countries where stone and burned clay bricks were common building materials, it was only natural that thought would be given to the use of clay which was far more common in many parts of the plains than was stone. It is not likely that there is any record of where the first bricks were made in what is now Saskatchewan. The early brick was no doubt made from surface clays, and, in the absence of machinery would have been hand molded in wooden forms. However, to come to more recent times, an attempt has been made to list all past and present places in the province where brick or other clay products have been made. It is quite possible some of the very small and earlier operations have been overlooked. The list, however, is fairly large and shows that no small amount of interest has been taken in the production of clay products in the province. No attempt has been made to single out the places as to their respective order of when they became active.

Arcola	Indian Head	Prince Albert
N. Battleford	Ile a la Crosse	Rosthern
Balcarres	Kamsack	Saskatoon
Broadview	Lloydminster	Shand
Bruno	Lumsden	St. Walburg
Carlyle	Meota	Weyburn
Claybank	Moose Jaw	Wolseley
Estevan	Pinto	Yorkton
Floral	Pilot Butte	

Some of the above undertakings were of very short duration, others lasted for a few years; at the present time there are only three active plants in the province, those at Bruno, Claybank and Estevan, plus the odd small summer brick yard like that at Yorkton. The question may be raised as to why the high percentage of fatalities; in answer there were several contributing factors or reasons. Among them there may be mentioned the following: in some cases the clay was not suitable, in others there was too much variation in the quality or quantity of raw materials, often too little capital or experience was available, production costs were too high to meet prevailing competition, outputs were too small to permit taking of large orders or to reduce manufacturing costs in line with the larger plants. Strong competition from both in and outside of the province, heavy slumps in demand during depression years such that those with limited capital could not carry over also contributed. To sum it up it is safe to say that in the majority of the cases the clays were not at fault; there were too many small plants with limited local markets, too little working capital and in some cases a lack of appreciation of the technical and business knowledge required to operate a brick plant successfully. Though the number of plants have been reduced, the capacity and output of the present large plants is equal to or greater than that of all of the earlier plants combined.

* STATISTICAL SUMMARY

The accompanying graph (Fig. I) illustrates clearly the dependence of the production value of Saskatchewan clay upon the demand for building materials. The four peaks record respectively: the early days of western expansion, from 1908-1912; the post-war period, from 1918-1921; the construction boom of the 20's; and the present post-war expansion. The three recessive periods recorded are: the period of the first world war; the business recession of 1922 to 1925, and the depression of the thirties.

* Prepared by The Department of Natural Resources.

While recorded production of common building brick and other clay products goes back to 1886, the production to 1920 was from numerous small plants producing mostly common brick, and a chronological history of their rise and fall is difficult to obtain from the records of those days. Some of the developments since 1920 may be outlined as follows:

1921—Face brick were being made at Estevan and Claybank while plants for the manufacture of common brick were located at Arcola, Bruno, Broadview, Prince Albert, Saskatoon, and Shand.

1922—The plant at Bruno in addition to common brick produced a line of structural building tile and some drain tile. The demand for all lines of clay products during the year was fairly good.

1923—Due to the depression there were only four plants active during the year, those at Estevan, Bruno, Claybank, and Prince Albert; the smaller plants remained closed.

1924—While fire brick and other refractories had been manufactured since 1912 at Claybank they were not so itemized from other clay products until the present year. The depression materially reduced all clay product production in the west.

1925—The International Clay Products Ltd., took over the dry press and stiff mud brick plants of the Estevan Brick and Coal Co. Ltd. and started on the production of stiff mud rough textured face brick.

1926-1929—There was a general increase in demand for clay products during these years so that all of the larger and some of the smaller common brick plants were in operation.

1933—During the year, the following plants were in operation—The Bruno Clay Works Ltd., The Dominion Fire Brick and Clay Products Ltd., The International Clay Products Ltd., The Shand Brick and Coal Ltd., and the brick plant at Prince Albert, owned by The International Clay Products Ltd.

1934—Outputs during the year were below normal due to the limited demand for structural wares. The Bruno plant remained closed.

1935—The demand was still weak; hence production was for a part of the year only. This year the Shand plant did not produce at all, though a small output of common brick was made by Malloff and Son at Yorkton.

1936—Production was a little below that of 1935 with the same firms operating part time only. A new firm, Western Paint and Tile Co. Ltd., was launched at Regina. The Canadian Clay Craft, a small art pottery was started at Saskatoon.

1937—The three large plants, The Bruno Clay Works Ltd., The Dominion Fire Brick and Clay Products Ltd., and The International Clay Products Ltd. were all producing during the year. Shipments of ball and stoneware clays reported though both had been mined and exported previously for a number of years, the ball clays to the United States and Medicine Hat, the stoneware clays to the latter point only.

FIG. 1

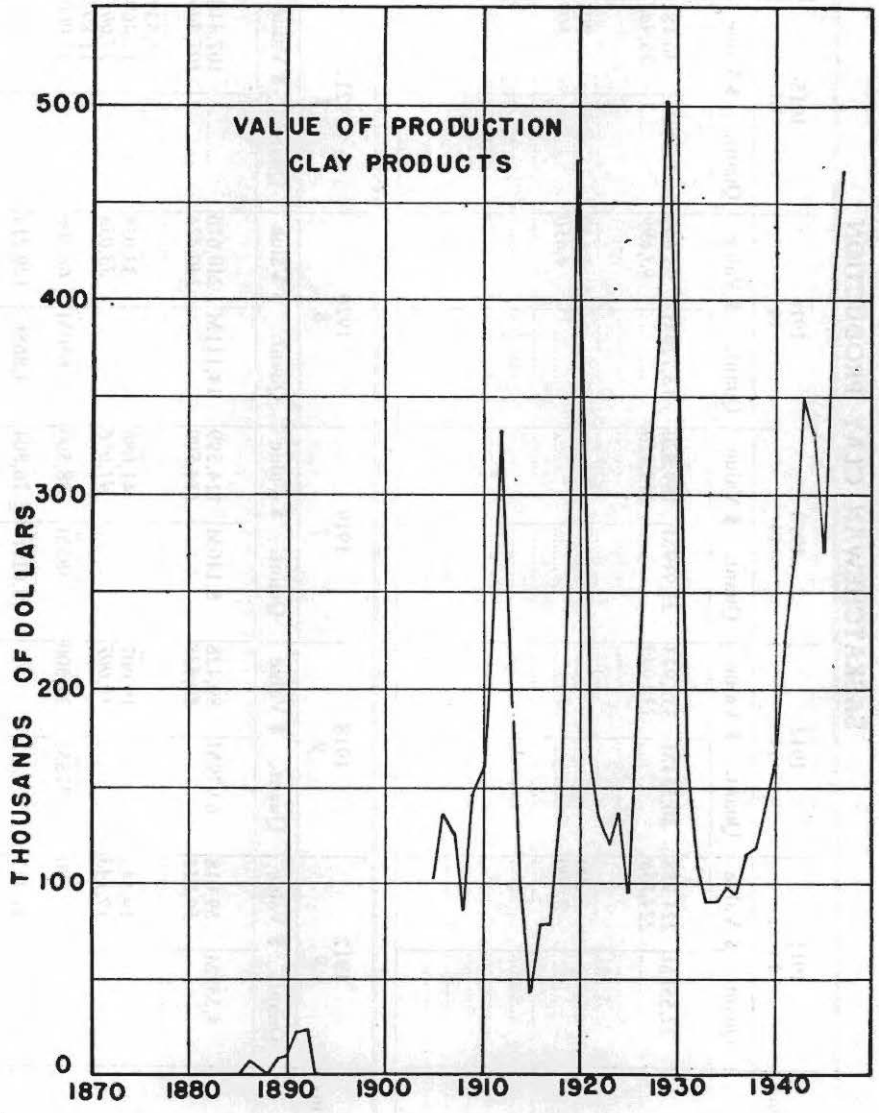

VALUE OF PRODUCTION
CLAY PRODUCTS
THOUSANDS OF DOLLARS
500
400
300
200
100
0
1870
1880
1890
1900
1910
1920
1930
1940

TABLE V

SASKATCHEWAN CLAY PRODUCTION

YEAR No. of Active Firms	1911 13		1912 14		1913 14		1914 14		1915 13		1916 11	
	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value
Brick	22,551M	224,758	30,554M	332,943	25,919M	189,820	13,720M	93,699	1,300M	36,482	5,331M	91,464
Total	.....	*224,758*	.....	*332,943*	.....	*189,820*	.....	*93,699*	.....	*36,482*	.....	*91,464*
Fire Brick	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fireclay	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Blocks and Shapes	.....	2,200	.....	.....	.....	.....	.....	4,650	.....	805	.....	7,000
Total	.....	*2,200*	.....	.....	.....	.....	.....	*4,650*	.....	*805*	.....	*7,000*
Hollow Blocks	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Drain Tile	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Floor Tile	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other Clay	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23,069
Other Products	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*23,069*

YEAR No. of Active Firms	1917 9		1918 9		1919 7		1920 8		1921 7		1922 8	
	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value
Brick	4,531M	59,018	6,979M	89,428	8,140M	114,599	14,111M	240,676	.....	107,346	.....	70,133
Total	.....	*59,018*	.....	*89,428*	.....	*114,599*	.....	*240,676*	.....	*107,346*	.....	*70,133*
Fire Brick	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17,010
Fireclay	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,532	.....	3,811
Blocks and Shapes	.....	19,143	.....	19,007	.....	41,086	.....	33,058	.....	12,469	.....	.....
Total	.....	*19,143*	.....	*19,007*	.....	*41,086*	.....	*33,058*	.....	*14,001*	.....	*20,821*
Hollow Blocks	.....	.....	.....	.....	.....	.....	.....	.....	.....	11,897	.....	.....
Drain Tile	.....	90	275M	27,500	385M	38,500	650M	68,500	.....	33,000	.....	.....
Floor Tile	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other Clay	.....	44,417	.....	.....	3,617t	76,804	4,868t	129,214	.....	.....	.....	.....
Other Products	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	*44,507*	.....	*27,500*	.....	*115,304*	.....	*197,714*	.....	*44,897*	.....	.....

TABLE V

SASKATCHEWAN CLAY PRODUCTION—Continued

YEAR No. of Active Firms	1923 8		1924		1925		1926		1927		1928	
	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value
Brick	.....	.....	.....	.....	.....	.....	5,497M	101,293	8,358M	136,858	11,887M	132,440
Total	.....	.....	.....	.....	.....	.....	.....	*101,293*	.....	*136,858*	.....	*132,440*
Fire Brick	.....	.....	.....	.....	.....	.....	737M	39,456	693M	37,085	713M	40,582
Fireclay	.....	.....	.....	.....	.....	.....	808t	5,103	1,008t	7,531	1,327t	9,183
Blocks and Shapes	.....	.....	.....	.....	.....	.....	.....	23,361	.....	61,634	.....	73,301
Total	.....	.....	.....	.....	.....	.....	.....	*67,920*	.....	*106,250*	.....	*123,066*
Hollow Blocks	.....	.....	.....	.....	.....	.....	4,400M	44,000	6,500M	65,000	10,120M	81,202
Drain Tile	.....	.....	.....	.....	.....	.....	20M	600	25M	800	15M	600
Floor Tile	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other Clay	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other Products	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	*44,600*	.....	*65,800*	.....	*81,802*

YEAR No. of Active Firms	1929 4		1930		1931		1932		1933 4		1934 3	
	Quant.	$ Valu	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value
Brick	14,301M	230,306	7,985M	135,926	.....	44,499	1,001M	12,450	121M	2,152	265M	4,176
Total	.....	*230,306*	.....	*135,926*	.....	*44,499*	.....	*12,450*	.....	*2,152*	.....	*4,176*
Fire Brick	809M	43,384	504M	28,001	415M	24,568	309M	15,200	391M	19,705	558M	28,537
Fireclay	754t	5,965	504t	3,920	484t	3,915	415t	3,111	371t	2,902	441t	3,322
Blocks and Shapes	.....	106,643	.....	118,122	.....	63,603	.....	66,688	.....	64,381	.....	52,276
Total	.....	*155,992*	.....	*124,843*	.....	*92,086*	.....	*84,999*	.....	*86,988*	.....	*84,135*
Hollow Blocks	13,257t	111,072	7,566t	60,214	3,177t	28,299	1,322t	11,781	210t	2,210	4t	45
Drain Tiles	25M	1,000	25M	1,000	.....	.....	.....	.....	.....	.....	.....	.....
Floor Tiles	.....	.....	739t	176	81t	20	.....	.....	.....	.....	.....	.....
Other Clay	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other Products	.....	4,152	.....	1,924	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	*116,224*	.....	*63,314*	.....	*28,319*	.....	*11,781*	.....	*2,210*	.....	*45*

TABLE V

SASKATCHEWAN CLAY PRODUCTION—Continued

YEAR No. of Active Firms	1935 4		1936 3		1937 4		1938 4		1939 5		1940 4	
	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value
Brick	477M	7,529	777M	19,175	375M	10,454	504M	8,700	982M	16,633	1,230M	16,632
Total	.....	*7,529*	.....	*19,175*	.....	*10,454*	.....	*8,700*	.....	*16,633*	.....	*16,632*
Fire Brick	272M	18,114	395M	19,676	522M	27,010	307M	16,765	474M	26,300	640M	34,710
Fireclay	670t	4,683	621t	4,665	771t	6,881	530t	5,120	671t	6,700	1,054t	10,352
Blocks and Shapes	.....	57,055	.....	46,968	.....	63,106	.....	62,595	.....	73,990	.....	64,518
Total	.....	*79,852*	.....	*71,309*	.....	*96,997*	.....	*84,480*	.....	*106,990*	.....	*109,580*
Hollow Blocks	1,098t	9,109	500t	5,100	700t	7,000	995t	8,119	790t	7,835	1,410t	12,698
Drain Tiles	.....	.....	.....	.....	.....	.....	.....	.....	5M	200	.....	.....
Floor Tile	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other Clay	.....	.....	.....	.....	3,942t	4,986	13,585t	17,414	9,153t	17,116	16,079t	25,918
Other Products	.....	.....	.....	.....	.....	3,012	.....	1,934	.....	3,214	.....	5,546
Total	.....	*9,109*	.....	*5,100*	.....	*14,998*	.....	*27,467*	.....	*28,365*	.....	*44,162*

YEAR No. of Active Firms	1941 3		1942 3		1943 3		1944 3		1945 4		1946 4	
	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value	Quant.	$ Value
Brick	921M	10,864	494M	6,494	36M	5,357	536M	9,230	753M	15,819	4,148M	92,185
Total	.....	*10,864*	.....	*6,494*	.....	*5,537*	.....	*9,230*	.....	*15,819*	.....	*92,185*
Fire Brick	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fireclay	1,320t	13,592	1,278t	13,109	1,497t	15,172	948t	9,133	1,170t	11,689	1,066t	8,906
Blocks and Shapes	.....	153,890	.....	178,129	.....	218,151	.....	194,824	.....	175,018	.....	180,697
Total	.....	*167,482*	.....	*191,238*	.....	*223,323*	.....	*203,957*	.....	*186,707*	.....	*189,603*
Hollow Blocks	1,625t	13,700	635t	5,300	725t	6,055	2,829t	23,503	3,335t	35,800	6,615t	85,043
Drain Tiles	50t	400	.....	.....	125M	5,625	85M	3,400	90M	4,050	150M	7,500
Floor Tile	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Other Clay	20,853t	32,451	20,097t	68,293	19,875t	98,363	18,315t	90,817	17,543	28,911	29,642t	37,112
Other Products	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	*46,551*	.....	*73,593*	.....	*110,043*	.....	*97,720*	.....	*68,761*	.....	*129,655*

1938—Outputs were by the same firms as during 1937 and with little change in volume.

1939—A small increase of output over that of the previous year. There was a lower demand for raw clays. The Canadian Claycraft closed for the duration of the war.

1940—There was a considerable upswing in the value of outputs for the year plus an increase of about 5,000 tons of raw clays for the year.

1941—With no increase in the number of producing clay product plants there was a gain of approximately 32 per cent. in output value for the year over that of 1940. The Midlaud Clay Co., miners of ball clay, ceased operations.

1942-43—There was a material increase in production and value during each of these years, largely through the larger demand for refractories created by war requirements. The export of clays to Alberta was also at a high.

1944—The plant of the International Clay Products Co., Ltd., was purchased by the Crown and became Saskatchewan Clay Products on December 31st. There was a slight falling off of demand during the year, but the total returns were still high.

1945—The Saskatchewan Clay Products was engaged during the greater part of the year in a rebuilding of the plant, dryer and kilns at Estevan. Production was started during the latter part of the season. Demand remained good; the plants at Bruno and Claybank were in full production, and the yard at Yorkton operated through the summer.

1946—The total value of the output of clay products made in the province was at a high, especially for structural wares such as building brick and hollow tile. In addition to the three large plants, the Yorkton brick yard was in operation from May to October.

The output of raw clay for export to Medicine Hat was the highest since 1938, as may been seen from Table VI.

1947—Three brick plants in operation in province—Dominion Firebrick & Clay Co., at Claybank, Bruno Clay Works Ltd., at Bruno, and Saskatchewan Clay Products, at Estevan. Clay leases on all hitherto unleased clay deposits on Crown lands awarded to Saskatchewan Minerals Corporation—Clay Products Division.

The statistics available in the records of the Dominion Dept. of Railways and Industries, the Saskatchewan Department of Natural Resources, and the Dominion Bureau of Statistics on clay and clay products production in this province, are not too well adapted to use in a report of this nature. For what they are worth, however, a production breakdown from 1911 to 1946 is shown in Table V.

For convenience, the "other clay" production (ball clay, stoneware or sewerpipe clay, and modelling clay) shown in Table V has been re-tabulated in the following Table VI.

TABLE VI

YEAR	OTHER CLAY PRODUCTION (Tons)
1938	13,585
1939	9,153
1940	16,079
1941	20,853
1942	20,097
1943	19,875
1944	18,315
1945	17,543
1946	29,642

ECONOMIC CONSIDERATIONS

While the province is well supplied with a wide variety of clays of good quality, it has never been a large producer of clay wares in comparison with, for instance, Ontario and Quebec. The chief reason for this situation has been that of the restricted western markets and the high cost of shipping finished wares to the more heavily populated and industrialized areas of Eastern Canada, areas which are supplied not only by the local clay product plants but by imports from the United States to the south and from overseas countries by water. Other reasons have been those of the competitive production of certain wares in Manitoba and Alberta; in the latter case, through the presence of an abundant supply of low cost natural gas, it has been possible for years to ship in certain Saskatchewan clays and manufacture them into wares such as pottery and sewer pipe, at lower costs than the same wares could have been produced at the clay deposits in Saskatchewan, notwithstanding the fact that in many instances coal (lignite) occurs with the clay. The same general conditions hold true for the production of structural clay products in Saskatchewan, in that they have to meet the keen competition of both building brick and hollow tile produced by the firms in Medicine Hat and Redcliff who

burn their wares with gas from wells on their own properties. There is small likelihood of the above conditions being greatly changed until a large supply of cheap natural gas becomes available in Saskatchewan. Therefore, in the meantime, since other general manufacturing costs with equally modern equipment should be little if any different in Alberta and Saskatchewan, effort must be made by local industry to reduce the cost of firing their ware.

The main reasons for the present differences in burning costs is the fuel, gas in the one case, and solid fuel in the other, and the extra labour required to distribute the solid fuel around the kilns, and to remove the ashes and clinkers during and following each burn. To illustrate, in the case of two average plants producing structural wares of the same kind from the same type of clay and the same number of units per day, the burning to be in kilns of the same type, then the ratio of firemen for gas in the one case and lignite in the other would be very close to 1:4 under favourable conditions and 1:6 for average. It may therefore be seen that even with an equal cost per heating unit for gas or for solid fuel delivered at the kiln, in the latter case the extra cost of the labour will make a very considerable difference in the burning costs. In the search for a means of equalizing burning costs, consideration should be given to better and more improved types of kilns, such as the modern car tunnel kiln, with mechanical stokers for firing the fuel. In this case the number of men required would compare slightly more favourably with that necessary with gas but not sufficiently so to equalize the costs. The solid fuel would have to be crushed and sized to feed uniformly, there would be the ash and clinkers to contend with plus the more rapid deterioration of furnace refractories due to slag action followed by the necessary clinkering; in other words higher up-keep charges would be necessitated by interval shut downs for repairs.

Lower grade wares like common brick, some structural tile and drain tile, may be burned in the top direct fired continuous kiln in which the finer sizes of coal may be used. There is one kiln of this type in the province which has been in operation for many years. While the burning costs per ton of ware in this kiln have been low, they could have been materially better had the kiln been of larger capacity, that is, sixteen chambers rather than the present eight. While with a kiln of this type, direct fired, it is possible to greatly reduce the burning costs over those of individual periodic kilns, it is to be kept in mind that they are not suited to the higher grade wares where ash dust would prove detrimental.

At present, except for one continuous kiln in Saskatchewan, the kilns in use are all of the periodic type, of which there are two kinds, namely, up draft, and, down draft. The former are open top kilns, rectangular in shape with furnace openings along the side walls. They are also known as "scove," or "clamp" kilns, and are for the most part used for the burning of common brick and some structural tile; they are more economical than are down draft kilns for the burning of such wares, in that most of the fuel is burned in close contact with the ware, but in the case of some clays frequent losses occur through overfiring or melting of the ware near the burning fuel. Kilns of this type, while widely used, not only in Saskatchewan but in other provinces and countries as well, are not suited for the burning of face brick, fire brick and other high grade products where uniformity of size, colour and other properties are essential.

In Saskatchewan the down draft type of kiln is used exclusively for the burning of fire brick and other refractories as well as most of the face brick, though some of the latter are burned in the more favourable parts of certain up draft kilns. While it is possible in down draft kilns to control the distribution of the heat, to maintain oxidizing or reducing conditions and produce a higher percentage of No. 1 ware than is generally possible in the case of up draft, it cannot be said that there is any large saving in the number of firemen regarding unit output. For example, depending on the clay, a thirty-two foot round down draft kiln will hold on an average ninety thousand building brick, and with eight hour shifts usually two men per shift will be required to fire the kiln when under full fire, while on the other hand it is not uncommon to operate up draft kilns holding from two to five hundred thousand brick per burn with six to eight men per shift where lignite is used. However, in most cases there is a considerable saving in the firing time of the down draft kiln, which tends to reduce the burning costs somewhat; its main or chief advantage is that of the more uniform and better quality of the ware than is generally possible in the up draft kiln. While the down draft kiln has its distinct advantages, it cannot, in the case of lignite or other coal as the fuel, be burned as economically as with gas, hence as long as Saskatchewan has to depend on solid fuel for most ceramic burning the down draft kiln does not hold the solution for meeting the competition of the more cheaply gas-fired wares from Alberta. While as stated above there are possibilities, through the use of car tunnel, or continuous kilns, of lowering the present burning costs in the province in relation to those of gas, they will not be sufficiently far reaching, and, furthermore there are wares which cannot be burned with lignite in its solid form as the fuel. Pottery, high fired face brick and other kindred lines are examples. The chief reason why this is so is not so much from the difficulty of attaining the higher temperatures but because of the fly ash and dust, which is carried by the kiln draft to settle on and among the ware where it finally melts to a slag which adheres to and spoils a lot of otherwise good ware.

It therefore becomes necessary to consider other ways or means of using the local lignite, such that a wide range of ceramic wares may be produced in the province under more

favourable burning costs than those of the present. It is a matter to which the author has given much thought and direct study over a period of many years, and in doing so he has steadily kept in mind the large investment in the kilns now in use in the province, though in due time they will no doubt be replaced by more modern types.

The conclusions which have been reached and advanced on several past occasions are that Saskatchewan lignite, to prove successful and economical for the burning of ceramic wares, should be converted into producer gas in modern gas machines, the high temperature gas from same then being conveyed directly to the furnaces of the kilns for burning. Kilns of the type now in Saskatchewan have for many years been satisfactorily fired with producer gas in the United States. It would therefore not be necessary to discard the local kilns now in use, and small alterations only would be necessary. The same is true in the event of natural gas becoming available.

There is no question regarding the production of a suitable producer gas from Saskatchewan lignite, as proven by tests (9) at the Mines Branch at Ottawa. The following table No. VII is taken from Report No. 83 (6).

TABLE VII

GAS PRODUCER TESTS ON SOURIS COAL

	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.

In addition to the favourable results of the gas tests made at Ottawa by the Department of Mines, there is direct evidence of its successful use for the actual burning of ceramic wares, in that producer gas made from lignite of the same age as that tested at Ottawa has for many years been used for the burning of high grade face brick, and fire brick, at the plant of The Hebron Brick Company at Hebron, N. Dak. At this plant it was produced in hand stoked producers and conveyed while hot from the producers direct to a Richardson chamber type continuous kiln, in which it was possible to burn the fire brick to cone 9, the desired temperature for their needs. Through private correspondence with the company regarding the obtaining of higher temperatures than cone 9 with the gas produced from their lignite, it was learned that with a proper producer capacity it would have only been necessary to have burned more gas to reach higher temperatures. In that the great bulk of heavy clay products are burned below cone 9, there should be little question regarding burning of same with producer gas made from Saskatchewan lignite.

Among the advantages to be gained through the use of producer gas for the burning of ceramic wares, particularly those known as heavy clay products, are a saving in the matter of labour costs for the distribution of coal around the kilns, the firing of the kilns and the ultimate removal of the ashes. With a producer the fuel is delivered at a single common point where it can be fed to the producer mechanically; the ashes as well are also removed by the same means. The kiln yard is therefore free and clean at all times of both coal and ashes. Furnace grates and bearing bars for the many furnaces required on kilns for solid fuel are completely eliminated. There are less repairs to be made on the furnaces and bag walls in that there is an absence of clinkers and slag action such as occurs from the ash of solid fuel. The control of the temperature at all periods of the burning is much better and can be more easily altered. There is a complete absence of fly ash or dust, therefore no spoiled ware from that cause. In addition to the ease of controlling the temperature, either oxidizing or reducing conditions can be maintained or changed as desired by means of valve control.

The gas is usually distributed to periodic kilns, either up or down draft, by means of underground brick flues, which are therefore out of the way and may be lengthened or extended in the case of more kilns being required. Quite naturally the cost of a producer installation must be justified by a sufficiently large plant output.

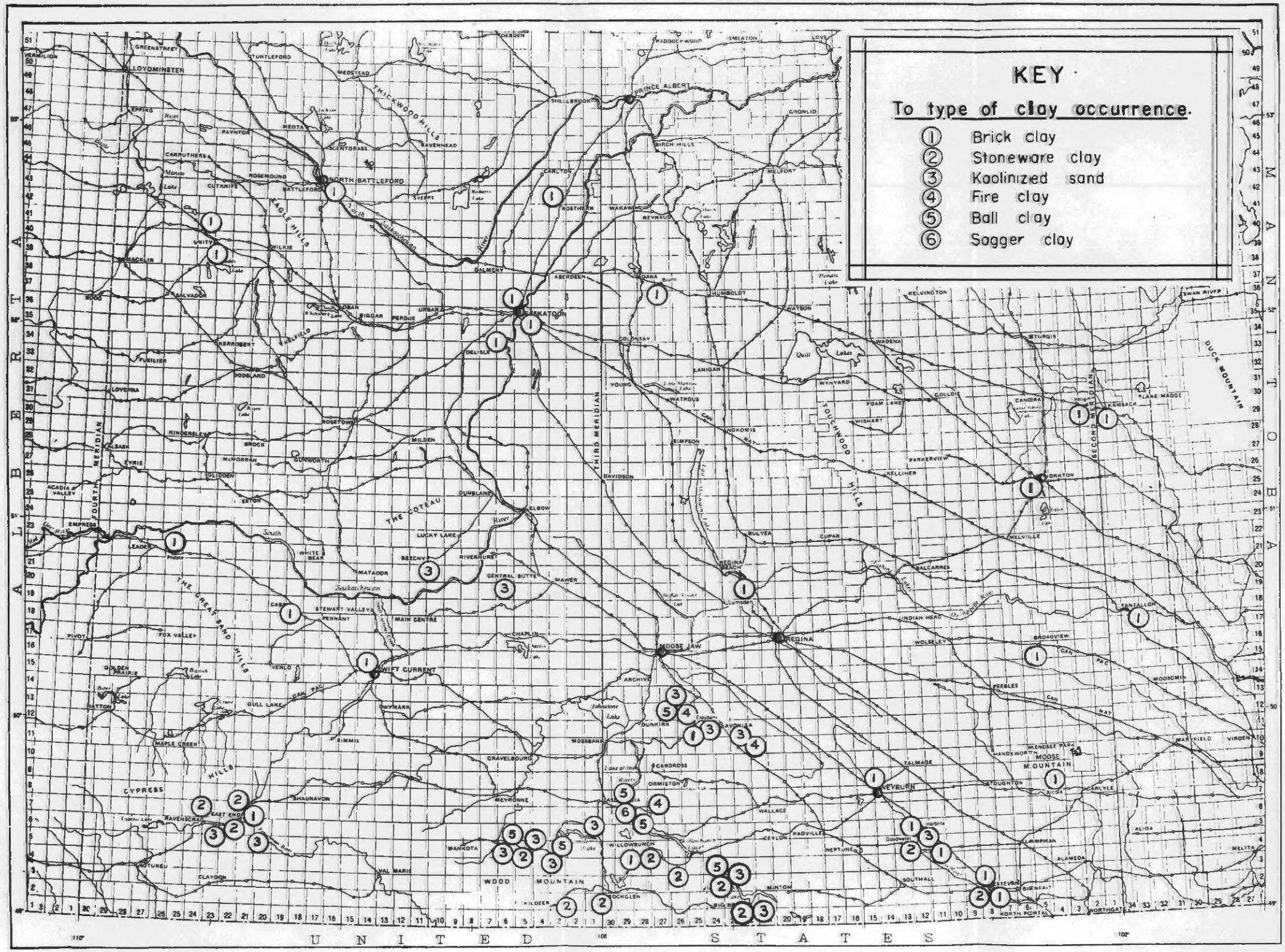
There are two general types of producers which have found use in the field of ceramics, and there are two methods of using the gas. As to type, there is the hand operated producer which today is obsolete due to the difficulty of obtaining and holding sufficient and suitable labour to operate them. The modern wholly mechanical producer, of which there are several standard makes, is the one to be given consideration. They are now widely used in glass plants in the place of natural gas, which in some cases is no longer obtainable at an equivalent cost to that of producer gas.

The two methods employed for the use of producer gas on ceramic plants are, first, to use it hot, directly from the producer, and second, to scrub, purify, and store it for use in a clean, cold state. The first method is more efficient from the heat recovery viewpoint, since the sensible heat in the gas at about 1,200°F. is not lost. Also the tar and other combustibles are also present which under other conditions would have been lost through condensation at lower temperatures or through their removal during purification of the gas in other cases. This method, however, cannot be used for all classes of ware, such as pottery and certain other glazed and decorated wares upon which colours are used that would be completely spoiled if burned with the raw unpurified hot gas, due in particular to the presence of sulphur contained in same. In such cases, the gas must be purified, and is usually stored in a large floating gasometer from which it is fed to the furnaces or kilns as required.

There may be cases where it would be desirable to operate the machinery of a clay products plant wholly by purchased electric power; if so, then there would not be the necessity of installing a steam power plant, and, in consequence there would not be available the usual supply of both live and exhaust steam for use in the dryers. In such cases it would be possible to install one or more boilers, the pumps, and other essential equipment to supply the necessary steam, all of which would be live steam, at a cost somewhat above that on plants using steam engines from which there would be a cheap supply of exhaust steam for at least one third of the time. In the absence of steam in an electrically operated plant, it becomes necessary to provide other sources of heat than that from steam, for drying purposes; a fairly common means of doing so has been through the use of radiated heat dryers, dryers with under floor furnaces and heat flues, the furnaces for the most part being hand fired with coal or coke, in the absence of natural gas or cheap fuel oil, though at an increased cost for labour and with some other unfavourable conditions. Any dryer of the sort can be heated equally as well with producer gas as with natural gas, provided producer gas is used for the burning as well. An example of this is the plant of the Kalamazoo Clay Co. at Brazil, Indiana, where for many years they have operated their periodic kilns and dryer with producer gas.

It is not to be understood that the radiated heat dryer has been mentioned as being the best, or that it is the only type of dryer in which producer gas could be used successfully. In those cases where one was or had been in use, fired by solid fuel, it could quite easily be altered for the use of gas. There are other ways open for consideration for its use of gas as the source of heat for drying, such as the use of two recuperators heated alternately by the gas, the accumulated heat of each then being available for drying or other heating purposes.

In conclusion, it should be fully recognized that a suitable fuel is essential to the production of most ceramic wares, and that the mere presence of a large supply of clays is not sufficient to the building up of a large, varied and successful ceramic industry, where it must meet strong competition. It is therefore imperative that in the absence of a local supply of natural gas, that serious consideration should be given to ways and means of bettering the local lignite for use in the field of ceramics.



Department of Natural Resources
and Industrial Development

4. Reports on Properties of Saskatchewan Clays and Shales

RECENT CLAYS

These are the soft, loosely consolidated clays of the province which have not been hardened to the condition of shales. They are of various colours or shades, usually yellowish, brown, grey or blue. Some are highly plastic while others are sandy or silty and therefore of lower degrees of plasticity. Those which were deposited in quiet waters are usually well stratified; those deposited under other conditions of the water are usually false bedded or badly mixed. Many of the clays are of glacial origin; they are non-stratified and usually carry pebbles and stones to an extent that in most cases they are of no interest for industrial use.

There are two types of the recent clays, those which burn to various shades of red, and those which burn yellowish; in the latter case the clays contain sufficient lime rock dust, or calcium oxide, to fade or otherwise mask the natural red colour which otherwise would be developed during the burning.

With the exception of the plants at Shand, Estevan, and Claybank, all of the brick plants which have operated in the province used, as far as known, these recent clays. The largest of them and the only one which has remained in business, is the Bruno Clay works, near Bruno. The clay used by this company for the production of structural tile, drain tile, and some common brick is that of a deposit formed in a lake area at the retreat of a continental glacier. The waters from the melting ice in their travel to the lake picked up and transported such clays as were in their path, and by this means the pebhles and stone of any earlier glacial clays were left behind, only the clay, fine sands, and rock dust finally reaching their destination where they are now found and used.

Other deposits formerly worked were either of the same general origin or that of river-terrace or flood-plain deposition such as formerly used at Prince Albert. Davis (5) reports a large deposit of glacial lake clay near Lancer, on the Empress branch of the Canadian Pacific Railway. This deposit is about 10 feet thick and is composed of inter-stratified thin bands of clay and silt. Bricks made from this clay dried safely and at cone 03 the colour was a good dark red.

Prospecting would undoubtedly find favourable recent clays quite suited to the production of the more common structural wares and red pottery such as flower pots. Precaution should be taken to prove thoroughly the depth, extent and uniformity of all recent clay deposits which may be under future consideration for development. Due to the conditions under which most of them were formed some may be found to change rather suddenly from clay to sand or silts; at times there are only pockets of these, then again those formed near a shore line are likely to change gradually from sandy clays to clayey-sands. In still other cases the clays may be so plastic and sticky that sands or sandy clay must be added to make them workable (such as releasing from the molds of a soft mud machine). In this respect it will be found that the silty or less plastic types of the recent clays are more suited to the soft mud process than to the stiff mud or dry press. On the other hand those of a plastic nature can best be worked by the stiff mud process. With a continuation of the past increased demand for common bricks the soft recent clays should prove of more interest than has been the case for some considerable time.

SHALES

In southern Saskatchewan there are no formations exposed below the Belly River of the Upper Cretaceous, though there are, as may be seen from the table, other shales lower down. Starting with the Belly River, shales are found to occur in all of the succeeding formations of the Upper Cretaceous and those of the Ravenscrag in the Tertiary. Thus, in so far as the quantity or supply of shale in southern Saskatchewan is concerned, it is so great that industrially it is not measurable. While there are hundreds of feet of thickness of shale in the total, it is not all suitable for the production of ceramic wares; some may be too impure, some too high in soluble salts, some possess unsuitable physical properties in the raw and/or burned states. The greater part of the Saskatchewan shales which have been tested have proven to be of the red burning type, especially those collected from the Belly River beds, the Bear Paw, (formerly known as the Pierre, by Ries and Keele (23) Davis (5) and others), the Eastend formation, the Estevan beds and some in the Ravenscrag. There are some, particularly in the Ravenscrag, which are so calcareous that they burn salmon at low temperatures, then become yellowish or light buff at somewhat higher temperatures, and then become overfired or melt quite suddenly to a greenish slag, changes which are common to most calcareous clays and shales. The only shales which have been used industrially in Saskatchewan are those which occur in the Estevan beds at Estevan, and those in the Ravenscrag at Shand, Estevan and in a limited way at Claybank.

ESTEVAN SHALES

The Estevan shale came into use during the early part of the present century, and has for the greater part of the time since then been extensively used for the manufacture of dry pressed red face brick. Care, however, has been necessary to avoid a certain amount of surface checking and some cracking of the ware between the time of pressing and the final temperatures

of burning. The cause of the checking results primarily from the extreme fineness of the clay grains and the presence of a large amount of colloidal matter; the latter greatly increases the drying shrinkage such that even in the case of the dry pressed brick it may be sufficient to form checks unless certain precautions are taken regarding the condition of the clay at the time of pressing, and later in the kiln at the start of the burn. They are: a close control of the moisture necessary for pressing, and a rapid removal of same from the kiln during watersmoking, as more fully discussed below. The percentage of water in the clay at the time of pressing must be held rather lower than for normal clays and it must be uniformly distributed or there will be sufficient shrinkage to cause checking. Another condition which may develop the same trouble is that of a weak kiln draft during the early watersmoking stage; if strong draft does not exist, then the whole interior of the kiln will become so filled with low temperature steam, that some of it may condense; if so, the ware under such conditions will absorb the moisture sufficiently to soften the surface back to a wet or semi-plastic condition. Finally with increase of temperature, drying shrinkage will take place in the damp surface film or layer and may result in checks or small cracks. It is obvious that the ware should therefore be set dry and the watersmoke should be removed at a rate to prevent any excess accumulation in the kiln. The use of a controlled dryer and car tunnel kilns would undoubtedly overcome much if not all of the trouble. Notwithstanding the fact that millions of brick have been made by the method employed, all commercial attempts to use the same material by the stiff mud process have proven unsuccessful due to drying defects, for the most part excessive drying shrinkage, and the slow rate at which the water of plasticity can be removed. This point has been clearly shown and explained by Phillips (22). At the Ceramic Dept. of the University during 1926, by means of pre-drying it was clearly proven that this shale when made into full sized brick by the stiff mud process could be safely dried within a normal period of time. The pre-drying temperature found necessary was approximately 550°C., which is somewhat higher than could be desired, but with the proper mechanical equipment and heating furnace the cost of pre-heating to that temperature should not prove prohibitive for high grade rough textured face brick and certain other structural wares. Quite naturally, gas or oil as the fuel would be most desirable.

RAVENSCRAG SHALE

The Ravenscrag shale used at the Estevan plant and formerly at the now dismantled plant at Shand is quite different in its raw colour and physical properties to those of the Estevan shale, the latter being of a blue shade, bordering on a lead grey when dry, and when tempered with water becomes highly plastic and somewhat sticky if a little too wet. The Ravenscrag, on the other hand, at the two places mentioned, is light yellow in colour or shade, is more siliceous, coarser grained, and is calcareous. While there are some variations as to its plasticity, it is for the most part well suited to the stiff mud process of manufacture of structural wares like brick and hollow tile, both of which under controlled drying conditions are dried safely. For some years past the Ravenscrag shale at the Estevan plant has been used for the production of the following wares: stiff mud rough textured face brick, side cut common brick—solid and with holes, end cut hollow brick, and a fairly wide range of hollow structural tile.

In addition to the differences of the raw physical properties of the two shales under discussion, the burned properties are different as well. The Estevan shale used for the dry pressed ware has a fairly long vitrification range and becomes dense with a low absorption. The burned colour varies from a salmon at cone 010, a light red at cone 07, to a good dark brick red in the general range of cone 02; at cone 3 or above overfiring takes place. The Ravenscrag material by the stiff mud process reacts quite differently during burning; at the low temperature of cone 010 it burns to a very light red, has an absorption of 25%, and the burning shrinkage is very low, being 1%. At cone 06 the colour changes to a light cream, the absorption has increased slightly, due no doubt to a small expansion of the body, a condition not uncommon in such clays. At cone 02 the colour remains the same and there is a further increase in the absorption, the shrinkage has recovered the expansion which occurred at cone 06. The shade at cone 3 is somewhat deeper, but the shrinkage and absorption have remained the same as at cone 02. With any material increase of temperature above that represented by cone 3, this clay fuses very suddenly to a yellow green slag such that the ware loses shape and may be stuck together near the furnaces. This condition is not common to this particular clay alone in that most all highly calcareous clays and shales have a very narrow vitrification range, such that it is not safe to carry their burning temperatures beyond the point where the absorptions are still high; therefore such clays or shales are for the most part confined to the production of common brick, land drainage tile, and some of the structural building tiles. In those cases where low absorption, hardness and high strengths are required, then those clays and shales which develop a good degree of vitrification should be used.

INDUSTRIALLY UNEXPLOITED SHALES

As before stated, shale has long been used in Saskatchewan for the manufacture of brick and other structural wares, mainly at Estevan and Shand where the shale outcrops, or is very near the surface, and in addition is associated with coal. There are, however, other areas and other shale formations in the province than those now in use, some of which may

prove of equal interest and importance in the future, especially so in the event of increased markets, or in those cases where natural gas or cheap fuel oil may become available at or near the source of the shale, which, of course, must be of good quality and free of defective physical properties to justify development.

In the past only the more favourable shale formations of the province were examined, others more distant from rail and of little immediate interest were left for future investigations. Some of these may prove as good or possibly better than some of those now in use, but ordinary shale cannot be transported very far economically, hence those deposits long distances from rail will not likely prove of much interest in the future in case all conditions remain as of today. In any event, a brief description of those shales in the province which are known to outcrop at or are near the surface are here reported with comments in the hopes that such may prove helpful in the future. They are:

The Lea Park (7)
The Ribstone Creek (7)
The Belly River—Pale & Variegated beds. (7)
The Bear Paw (7)
Millwood (5)
Odanah (5)
Ashville (12)
Vermilion River (12)
Keld-Assiniboine (18)
Morden-Boyne (18)
Pembina (18)
Riding Mtn. (10)

The Lea Park Formation

This is marine in origin and for the most part consists of dark coloured shale in the lower zones, but well up in the beds the shade changes to greyish, and there are bands of fine-grained sand and sandy shale, with layers of ironstone nodules near the top. In Manitoba it is correlated with the Boyne. Outcrops of the Lea Park are not numerous nor of very great depths; possibly the most easily accessible one is that near the north approach to the first bridge on the highway between North Battleford and Battleford, though this is not necessarily one of the better zones. There are many showings on both sides of the North Saskatchewan river from the above mentioned exposure up-stream to the Alberta border in township 53; other outcrops occur on some of the small streams which enter the main river both from the north and south sides. Along the Battle River for a few miles up-stream from Battleford are other exposures, and they appear again on the same stream southeast of Buzzard on the Canadian Pacific Railway. While the Lea Park beds have not been examined, they should be given consideration, on account of some of them being within close proximity of the Lloydminster oil and gas fields.

Ribstone Creek Formation

This formation occurs geologically just above the Lea Park and outcrops in the same general areas as that formation. In that it consists of grey coloured shales, some of which are sandy, it may quite easily be mistaken for the Lea Park by those unfamiliar with this geology. One feature peculiar to it are thin coal seams; in addition there are some greenish grey sands and sandstone not reported as occurring in the Lea Park.

There are exposures in the Eagle Hills, particularly north and east of Prongua, a small village on the Canadian National Railway, and also south of Buzzard as referred to under the discussion of the Lea Park formation. There are a number of showings along Big Gully Creek to the north east of Lashburn, though their distance from rail would very greatly reduce their value and interest regarding development. Those near Prongua, Buzzard, and north of Paynton should be examined because of their nearness to a supply of gas or oil. They have not been tested through the laboratory; therefore, it is not possible to report on their general properties.

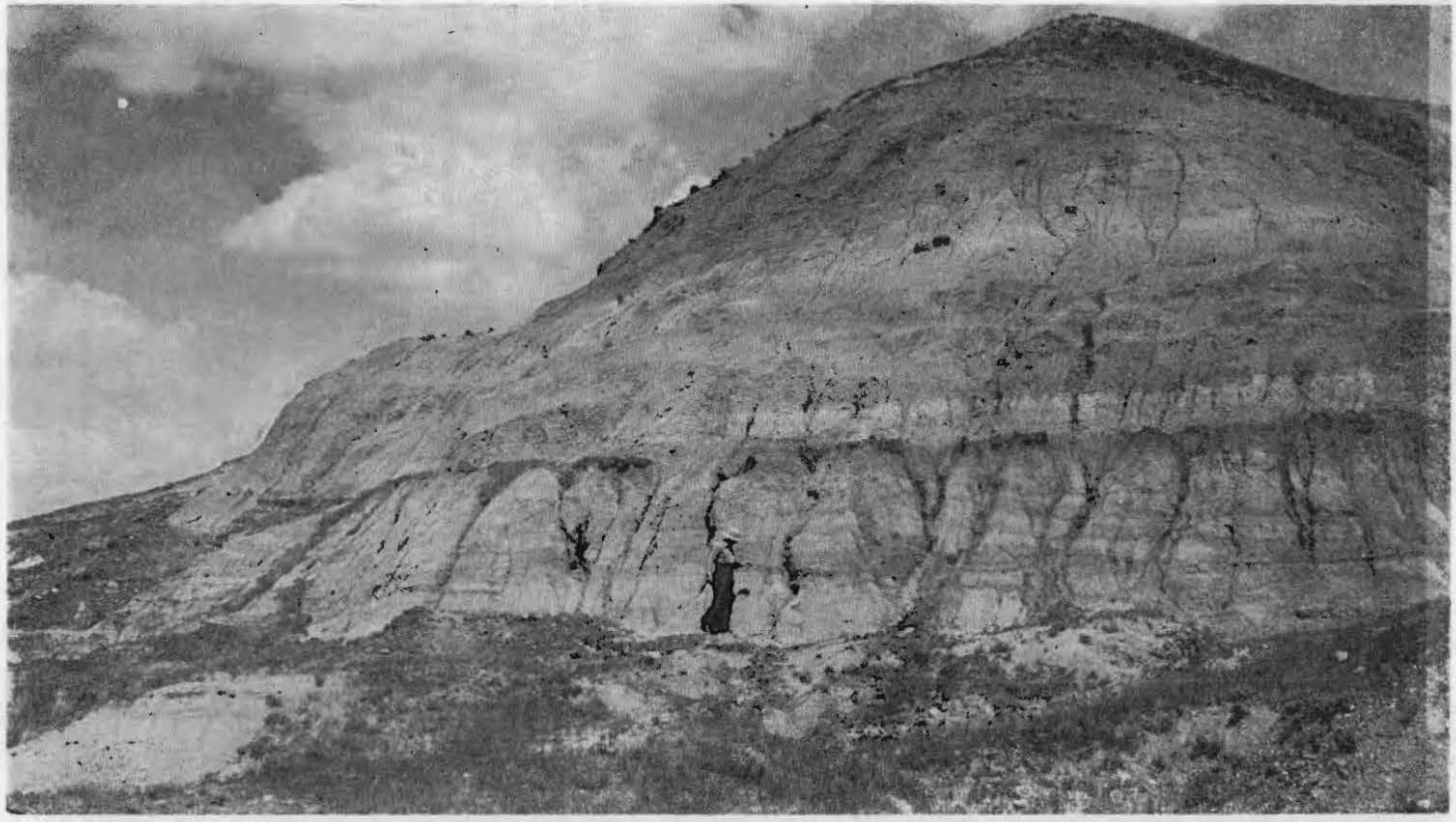
Belly River — Pale and Variegated Beds

While the Belly River in Alberta, is, for the most part non-marine, more eastward and northeastward in Saskatchewan it is largely marine and includes beds equivalent to the Lea Park, the Boyne of Manitoba, and other formations which are here treated as to their interest ceramically, leaving their geological aspect to the detailed reports of the publications of the Canadian Department of Mines, Geological Survey.

Exposures of the Belly River occur on both banks of the South Saskatchewan River in ranges 15, 16, 17, and 18, more in particular from Saskatchewan Landing up-stream, where there are buff sandstones and shales which are greenish buff and purple, plus rusty clays and sands. These particular beds are of questionable distance from transportation at present to be given any serious consideration regarding their industrial use.

To the north, near Herschel, there are low exposures of light grey sandstone and shale, a buff-coloured rusty marine sandstone and a thin seam of coal. In that the outcrops at this point are at rail they may in time be worthy of attention.

Farther north in the areas of Muddy Lake and Unity there are a number of well exposed sections of the Pale beds, made up of light to dark grey shales, light grey bentonitic sandstones, thin coal seams, and in places ironstone nodules. In that gas has been found to be present in the same areas, the shales are of particular interest and should receive a thorough and careful



Clay, silt, bentonitic sands and shale beds south of Unity, Sask., near Muddy Lake.

study regarding their use for clay products. From a limited number of tests made on samples collected during the late fall of 1945 and early 1946 it was found that some of the shale beds offer promise of being useful in the production of structural wares, such as brick and building tiles, red in colour. While the work was not extensive, there was no evidence of pottery clays being present. There are both highly plastic and short, sandy shales which are of interest for blending such that shrinkages and burning temperatures may be generally controlled.

All of the burned trials were quite badly scummed, resulting from soluble salts in the shales. Conditions of this sort, unless too extreme, can be corrected through the use of chemicals. It is possible that the salts may be less deep under cover than at the outcrop where they have no doubt accumulated through evaporation of the water carrying them out from the main body of the deposit. Three of the samples gave promise of being useful for the production of "Haydite" (bloated burned clay).

The largest exposures are in sections 11-12-T.39-R.23-w3rd, roughly 7 miles south and two west of Unity. The distance for the location of a plant on rail in Unity is rather more than would be economical for the moving of raw material for the manufacture of low priced heavy wares like brick and tile. It is to be recommended that attention be devoted to areas at or close to the town.

In that there is an abundant supply of natural gas now available at Unity, and with the salt refining and no doubt other industries to be located there, plus two railroads for reaching other than the local market, the interest for further ceramic field work and testing in that area seems well justified.

Bear Paw

This formation extends over a very large area of Saskatchewan, particularly in the southwest where outcrops are fairly common along the Frenchman River in T.5-Rgs. 14, 15, 16, -w3rd and farther southeastward. They also outcrop along Notukeu Creek northeast from Ponteix, and on both sides of the South Saskatchewan River from T. 20, R. 12 downstream nearly to Outlook. In addition there are many other showings.

These are beds of shale, which for the most part are dark grey to brownish, fine grained and bentonitic, some of them breaking down easily into a sticky, fine grained clay when wet. There are some sandy zones, ironstone concretions, often containing fossils; selenite crystals are common and some barite crystals are found. Iron stain discolours some of the shales and sandy beds.

Though the Bear Paw formation is rich in shale, and easily accessible over large areas of the province, past tests by the author and others have not found it to be of much interest for the manufacture of clay products. The burned colour, red, is satisfactory, but the drying and total shrinkages, have in every case, been found to be abnormal, such that severe cracking takes place during the drying period, plus either cracking or twisting during the burning, and in addition scumming by soluble salts is very bad and would have to be corrected. In view of the defective properties of the Bear Paw shale, and the occurrences of better clays and shales in the province, there seems to be little to commend them for early attention at least. It may be suggested at this time that the dry press process of brick manufacture is the one offering the most promise for the use of these shales.

Millwood and Odanah Shales

In the report by Davis, (p. 82) (5) these shale horizons were mentioned as occurring in the Pierre formation near Tantallon in the Qu'Appelle Valley.

More recently, however, on the Regina Sheet, Map 267A (7) the marine shales series has taken the place of the Pierre, and on Map 713A, (12) Assiniboine, they are shown in the Riding Mountain Formation. The chief interest at the moment concerns their general properties and possible values to the future development of ceramics in Saskatchwan.

To this end Davis and the author in turn have examined deposits in the above area and have conducted a number of preliminary tests, sufficient to bring out their more important properties.

Millwood

At the south side of the valley from Tantallon there are showings of the Millwood shales; they are dark brown, reddish to chocolate and grey. They weather easily and become plastic fine grained clays at the surface. The drying shrinkage is too high when tested in the stiff mud condition, and severe cracking occurred with scum on the surface of the trials. The burned colour at cone 05 was a good red and the absorption very low. To use this shale by the stiff mud process it would be necessary to blend it with a portion of the Odanah which is just above it.

Odanah

Though this shale rests on the Millwood, it is quite unlike it. The Odanah, while dark if damp, is greyish when dry. It is hard and breaks down into splinter-like fragments which resist weathering, only a small portion softening or disintegrating into clay. It is for this reason that it would serve as a source of grog for the Millwood. When finely ground and well

tempered, it develops a fair degree of plasticity such that it could be run through an auger type extrusion machine. A small addition of the Millwood more plastic shale would no doubt prove beneficial. Its burned colour at cone 05 is that of a good brick red. The total shrinkage at that cone is normal, but the absorption proved to be higher than would be desirable for face brick and other exposed wares. This property could no doubt be improved through a blend of the low absorption Millwood.

In these two shales, associated as they are, and of widely different properties, except for burned colour, there is offered one of the more favourable opportunities in the province for development as far as the raw materials are concerned. There is, however, the matter of fuel to be given equal consideration, in that with solid fuel, it would be difficult to meet the competition of gas fired ware. It should not be assumed that further prospecting and the conducting of plant size tests are not necesssary. It would be most unwise to do otherwise in that the investment required for an average size structural wares clay plant today is so high that every possible angle should be thoroughly investigated.

Ashville

The Ashville Formation is composed of dark grey shales, some bentonite, silts, sand and limestone. While there are many exposures of these beds in Manitoba, the only place where it is mapped as occurring in Saskatchewan is in that part of Thunder Hill which extends into the province in T. 35-R. 30w1st, northeastward from Pelly. McLearn and Wickenden in their preliminary report on the "Oil and Gas Possibilities of Hudson Bay Jct. Area" Canadian Department of Mines, Paper 36-8-1936,-p. 4, make reference to outcrops of the upper part of the Ashville as being exposed along the Red Deer River from Erwood to a little above the site of the Trail Blazer well in T. 44-R. 2w2nd. The beds in that area were dark, partly carbonaceous and almost fissile shale.

In that the Ashville shales at neither of the above localities have been examined for their ceramic values or interest, nothing can be reported as to their properties. Those in Thunder Hill are rather distant from rail for economical development, while those along the Red Deer River, unless favourable deposits exist at or very near to Erwood, would be under the same handicap of distance.

Vermilion River Formation

This formation consists of dark grey shales, calcareous speckled shales and bentonite. The main outcrops of it which may be seen in Saskatchewan are those which occur along the Swan River, north and northeastward from Pelly in T. 34, Ranges 30-31 and 32-w1st. Some of the outcrops, especially along small tributary streams from the south in T. 33-R. 31, are not far from the Canadian National Railway, but from a hurried visit to that area in 1944 the author found the beds to be badly distorted or slumped, due no doubt to the presence of bentonite seams. A snap sample taken of the dark shale, while not representative of the beds as a whole, when tested had a drying shrinkage of 6.6 per cent. and at cone 02 a fire shrinkage of 12.9 per cent., a total of 19.5 per cent. and an absorption of 21 per cent. at the same cone. The burned colour was an off shade mottled buff. The shrinkage and absorption are both too high and if generally representative of the beds as a whole, then they are not of great promise. They should, however, be more thoroughly sampled.

Keld-Assiniboine

Overlying the beds along the Red Deer River, assigned to the Ashville by McLearn and Wickenden, there is a zone of calcareous siltstone, silt and dark shale which they tentatively include in the Keld-Assiniboine. Exposures of it are reported along the river in T. 44-R. 3w2nd, southeast of Hudson Bay. In so far as known the shales in this area have not been examined by a ceramist.

Morden-Boyne

These are calcareous speckled and dark shales. McLearn and Wickenden report that little if any of these shales are exposed in the area of their work along the Etomami River in T. 42 and 43 and Ranges 3 and 4, w2nd, southwest of Hudson Bay, though in one locality near section 13-township 43-range 3w2nd there are shales at the surface which may be of these beds. They have not been examined as ceramic materials.

Overlying these dark shales, though with no clear boundary, there are calcareous speckled shales with interbedded, non-calcareous, dark shales like the Boyne. They are exposed at the surface at various points along the Etomami River from about S. 3-T. 43-R. 3w3rd to the NW. 14-T. 42-R. 4w2nd. Outcrops of these beds were examined briefly in 1944 by the writer when small preliminary samples were taken for testing. Sample 4402 required 50% of water for tempering, its drying shrinkage was 19 per cent. and it bloated during the burn at cone 04 and above. The colour ranged from a light clear red at cone 010 to a dark brownish red at cone 1. Other than for "Haydite" this material is of questionable value for ceramic uses. Sample 4403, taken up-stream from a different bed, required the very large amount (61%) of water for tempering, and the drying shrinkage (18%) is abnormally high. The burning shrinkage of 10.8 per cent. at cone 02 is also high for clays and shales of the same general

class. The total shrinkage at cone 02 is 42.4 per cent., but the absorption of 8.4 per cent. at cone 07 has dropped to 0.0 per cent. at cone 02. The burned colour, red, is good, bloating did not occur, except in one trial piece at the highest temperature used, cone 5. All trials were free of scum.

It is not possible to suggest any uses for this shale as a material for the manufacture of clay wares by the stiff mud or soft mud processes. Any further work with shales from these beds should be regarding their use by the dry press method, which may overcome a large part of the shrinkage.

Pembina

This formation overlies the Boyne, and consists of dark carbonaceous, friable and almost fissile shales with numerous seams of bentonite, particularly near the top and bottom. In the Kakwa well it was from 30 to 40 feet thick. There are outcrops along the Etomami River, principally in T. 42 and ranges 3 and 4w2nd. These beds were not sampled and therefore no tests can be reported on.

Riding Mountain

This is the uppermost horizon of the Cretaceous in the Hudson Bay area, and outcrops along the Etomami River down-stream from Bertwell (formerly Kakwa) to about S. 14-T. 42-R. 4w2nd. It consists of grey, plastic, bentonitic, non-calcareous shales with numerous clay-ironstone concretions; in some cases there has been slumping of the beds. A sample of it was collected at a point near the railway bridge at Bertwell, and though at the place of sampling, the shale was somewhat shattered or broken down, the stratification was evidenced by the presence of thin stringers of ironstone concretions. These were not included in the sample No. 4404. The clay when tempered with 56.4 per cent. of water was highly plastic and workable. but its drying shrinkage of 17.5 per cent. was abnormally high, as in the case of the other samples collected along the Etomami River. The burning shrinkage ranged from 6.4 per cent. at cone 07 to 11.4 per cent. at cone 02; in the latter case this gave a total of 28.9 per cent. which is excessive and would result in much loss of ware. The absorption becomes practically nil at cone 02. The burned colour is that of a good brick red. Slight bloating took place at cone 1 and above.

From the limited number of samples tested from the shale beds along the Etomami River the results are of a distinctly negative nature in so far as the use of the shales for industrial clay products is concerned. However, in view of the finding of some gas in the wells drilled at and near Bertwell (Kakwa) it would seem advisable, at some future time, to make a detailed study of the shales in that area to ascertain if there are more favourable beds or zones than those tested.

GENERAL COMMENT ON SHALES

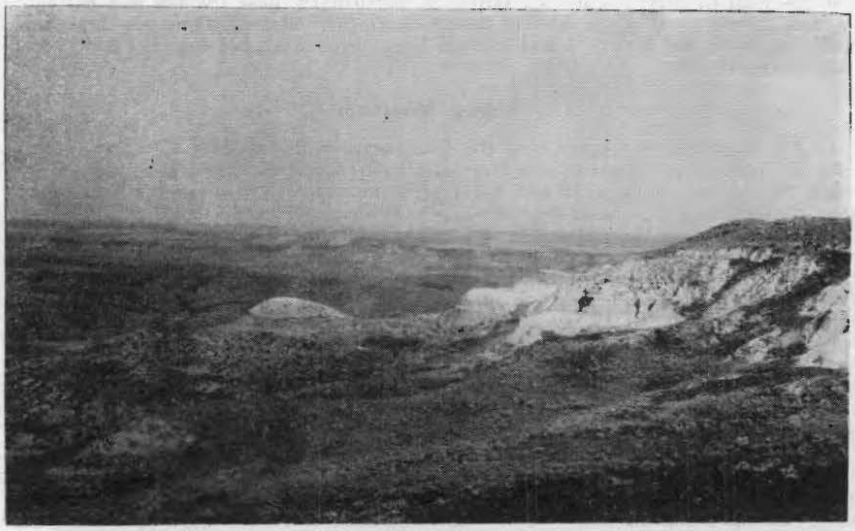
In further reference to shale, those in the general area of Kamsack should be examined in that gas has also been found, though up to the present not in large quantities. There are some indicated showing of shales in the Riding Mountain formation at Kamsack Creek south of the village, and also on Whitesand River, northwesterly from Kamsack, and it is likely that the beds can be found elsewhere in the general area. Keele (Memoir 66, No. 54 Geological Series) mentions the occurrence of shale (Niobrara) beneath the surface clay used by the Kamsack Brick Co. at that time. The shale was of a brownish shade near the surface, but dark grey below. It contained selenite crystals scattered through the deposit. A sample of the shale was of good plasticity when tempered, but was stiff and hard to work. The shrinkage was high and the trials cracked during drying. The burned colour at low temperatures was red, but unless fired slowly it would bloat. Further testing should include its use by the dry press process of brick manufacture. The selenite (gypsum) crystals would prove objectionable, due to scumming when soluble, and forming white spots or specks if not very finely ground during the preparation of the shale. Other zones or beds free of the crystals should be located.

In addition to those areas of shale which have been dealt with in this report, there are many others where shale is known to be exposed or at least near the surface, though in most cases they are too far from rail to be of interest at present, and in most cases the same types are known to be at rail or within reasonably short haul distances.

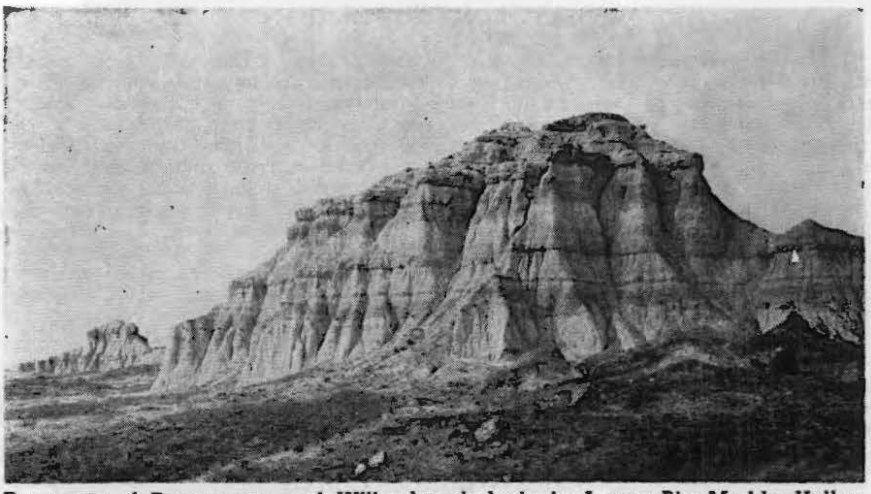
WILLOWBUNCH CLAYS

In selecting the clays to represent those of the Willowbunch member of the Ravenscrag, no attempt has been made to include all of the samples which have been collected and examined over several years of field work, but rather to take a general average of them as a whole, and further, to include some from each of several well known areas in which they occur. The reasons for so doing were first: to present the general properties of the clays as a whole, secondly: to set forth any differences between those of the type area, Willowbunch, and other districts or areas, and, thirdly: to try to classify into type groups. It is desired, in addition, to direct the attention of those further interested in these clays and their geology to the extensive work of McLearn (14) and others, and it is noteworthy that he speaks of two distinct Whitemud zones, as well as a possible third one high up in the buff division of the

Ravenscrag west of the village of Willowbunch. This third zone was later (15) given the name of the Willowbunch member of the Ravenscrag formation, and considerable detail was given on the clays of the Willowbunch area. On page 36B (16) he calls attention to the presence of other zones of semi-refractory or refractory clays both above and below the main Willowbunch member. Special mention is made of a higher thin zone south of Harptree, and a lower one near Rockglen. These had also been noted by the author of the present report, who has more recently located similar clay beds farther east in the Goodwater and Estevan areas. While these additional semi-refractory and refractory clay zones, above and below the main Willowbunch clays, are known to occur, they are not in the present case being separately treated, particularly so in that their physical and pyrometric properties as well as their industrial importance and uses are so closely allied to the main type of clays that they can be treated together.



An outcrop of Willowbunch clays on S. 21 - R. 23 - 3 - W2nd, near the west end of Big Muddy Valley.



Remnants of Ravenscrag and Willowbunch beds in Lower Big Muddy Valley, near the United States border.

In further connection with the Willowbunch clays, it is desired to call attention to the excellent report on same by McLearn and McMahon (17) and of course reference should be made to the major report, Memoir 176 (6).

The Willowbunch clays, in so far as their purity and refractory qualities are concerned are not the equal of the Whitemuds, though on the other hand, they are of very great industrial importance to the future ceramic development of the province, in that except for whitewares and high grade refractories, they can be used for a very wide range of ceramic products, particularly structural wares, yellow ware, stoneware and other products requiring low

absorption. Their occurrence with coal is a matter of economic importance which should not be overlooked, and in certain areas like Willowbunch, Harptree, Rockglen, and other points, water is available from large springs issuing from the coal seams.

In general the Willowbunch clays are of three types, those which are highly plastic, others of medium plasticity, and those which are rather lean due to their sand content. It thus becomes possible through blending to develop a wide range of wares. From an analysis of the data regarding those Willowbunch clays noted in Tables VIII and IX, it has been found that in addition to a division of them as to their plastic properties, they can, through a comparison of their water of plasticity and drying shrinkages, be further grouped into four types. These are, first: those which range from a low of 38 per cent. to a high of 42.6 per cent. (average 40 per cent.) water of plasticity and an average drying shrinkage of 13.2 per cent.; they are the most highly plastic. Second: those which range from a high of 36.4 per cent. to a low of 30.7 per cent. (average 30.1 per cent.) water of plasticity, with 8.6 per cent. as the average drying shrinkage. Third, those with a high of 28.9 per cent. and a low of 23.0 per cent. (average 27 per cent.) water of plasticity, and with 7.3 per cent. as the average drying shrinkage. Fourth: the sandy group with a high of 20.4 per cent. and a low of 17.8 per cent. (average 19.6 per cent.) water of plasticity, the average drying shrinkage being 6.1 per cent. The above well illustrates the fairly wide properties of the different beds of the Willowbunch clays, and, that through blending, under control, suitable mixtures can be made for a variety of wares.

These clays are of further interest due to the low temperatures at which they become steel hard, the general average being below cone 02, a few as low as cone 010, thus indicating that these clays start to vitrify and gain strength at quite early temperatures. In respect to bluestoning, there is a wide field to select from; a few at the temperatures tested did not show any signs of same, but the majority, however, were found to develop the usual bluestone greys of typical stoneware clays. The range at which they start to or become bluestoned is quite wide, the low being at cone 04 and the highest at cone 8, the majority from cone 3 to cone 6 inclusive. In view of such a wide spread from cone 04 to cone 8, it will be advisable, for those interested, to pay careful attention to the selection of their clay or clays such that they obtain those which do not bluestone too early or too late for the particular temperature and ware which it may be desired to manufacture.

In general the more highly plastic clays of those under discussion are those which are brownish, chocolate, and occasionally nearly black. The medium plastic are lighter in shade, either light or dark grey, and at a distance when dry they appear quite white. The less plastic ones are mostly light in shade, some off-white, cream or yellowish from iron stain, though in a few cases they were found to be brownish from organic stain.

The total thickness of the Willowbunch beds is in general less than those of the White-muds, and as is the case with the latter, the individual beds vary in thickness from place to place. While there are many exposures or outcrops of these clays, they are for the most part high up in the hills or valley sides and in many cases are under heavy overburden. It is, therefore, advisable to conduct a careful survey of all deposits in a given area so that the most favourable conditions may be taken advantage of for either open pit working or underground drift mining.

It may be mentioned that the Willowbunch clays are of interest for consideration in the manufacture of yellow ware, stoneware, terra-cotta, sewer pipe, fire proofing, face and common brick, hollow tile, quarry tile, and other allied lines of ware. Some of the dark ones are of interest as bond clays to be used with others of low plasticity, or where a body must carry considerable grog.

TABLE VIII

RAW PROPERTIES OF WILLOWBUNCH CLAYS

WILLOWBUNCH AREA

Sample No.	General Raw Colour	Thickness Sampled	Location	% Water of Plasticity	General Working Properties	% Drying Shk.	General Remarks
2822	Dark grey	10 ft.	N½-22-5-28w2	35.0	Good	10.8	Overburden up to 35 ft. where sampled.
2832	Dark brown	8 ft.	NW.-15-5-28w2	28.9	Good	10.1	Overburden up to 30 ft. where sampled.
2835	Chocolate	10 ft.	S½-22-5-28w2	33.1	Good	8.7	Overburden up to 15 ft. where sampled.
2837	Dark grey	10 ft.	SW.-22-5-28w2	36.3	Good-sticky	9.6	Overburden up to 12 ft. where sampled.
2839	Light grey	4 ft.	SW.-23-5-28w2	33.4	Good-sticky	10.0	Overburden excessive where sampled.
2844	Chocolate	6 ft.	S½-14-5-28w2	42.6	Good-sticky	10.9	Overburden excessive where sampled.
2845	Greyish	4½ ft.	S½-14-5-28w2	33.8	Good	9.7	Occurs just above last sample.
2848	Dark grey	5 ft.	SE.-14-5-28w2	32.4	Good	10.6	Overburden up to 10 ft. where sampled.
4108	Nearly black	3 ft.	SE.-14-5-28w2	41.2	Little sticky	10.5	Overburden up to 25 ft. where sampled.
4109	L. Chocolate	3 ft.	SE.-14-5-28w2	31.8	Good	8.8	Occurs just above 4,108.
4110	Light grey	3 ft.	SE.-14-5-28w2	32.7	Good	10.0	Occurs just above 4,109.

BONNEAU LAKE AREA

2859	Nearly black	10 ft.	N½-4-5-27w2	38.4	Sticky	13.1	Lower 4 ft. sampled. Overburden up to 35ft.
4111	Light gray	2½ ft.	W½-10-5-27w2	26.8	Good	6.3	Overburden up to 15 ft. where sampled.
4112	Dark gray	10 ft.	W½-10-5-27w2	31.2	Good	11.2	Overburden nil at point of sampling.

HARPTREE AREA

3018	Nearly black	4 ft.	NE.-5-4-26w2	38.0	Good	14.2	Overburden up to 20 ft. where sampled.
3019	Light grey	5 ft.	NE.-5-4-26w2	26.3	Very good	7.7	This occurs just above 3018.
3020	Mixed, dark	7 ft.	NE.-5-4-26w2	34.8	Good	14.0	This occurs just above 3019.
3023	Very dark	7 ft.	SE.-5-4-26w2	36.3	Sticky	12.7	Overburden excessive, where sampled.
3025	Med. grey	19 ft.	SW.-5-4-26w2	26.1	Good	8.3	Overburden nil (a butte).
3030	Med. grey	4½ ft.	NE.-33-3-26w2	35.8	Good	11.6	Overburden excessive.
3031	Light grey	10 ft.	NE.-33-3-26w2	34.6	Good	7.7	Overburden excessive.
3124	Light grey	12 ft.	SW.-5-4-26w2	23.0	Fair	6.0	Somewhat sandy..

TABLE VIII—*Continued*

RAW PROPERTIES OF WILLOWBUNCH CLAYS—Continued

BIG MUDDY AREA							
3061	Cream	6 ft.	SE.-21-3-23w2	24.2	Good	5.4	Somewhat sandy.
3062	Iron stain	4 ft.	SE.-21-3-23w2	35.5	Good	10.9	Somewhat silty.
3063	Very l. grey	5 ft.	SE.-21-3-23w2	28.8	Good	7.7	These three beds occur together.
LOWER BIG MUDDY VALLEY AREA							
2747	Dark grey	2½ ft.	7-1-22w2	35.9	Fair	13.6	Fine grained and of a greasy feel.
2748	Dark grey	4½ ft.	7-1-22-w2	36.4	Good	12.4	Somewhat sandy.
2749	Dark grey	6 ft.	7-1-22w2	17.8	Good	9.2	Somewhat sandy.
2750	Chocolate	4½ ft.	7-1-22w2	28.3	Good	10.8	Fine grained, some iron stain.
3120	Light grey	6 ft.	7-1-21w2	28.8	Good	9.6	Medium coarse.
4644	Light grey	10 ft.	30-1-21w2	20.4	Fair	4.0	Somewhat gritty. Occurs under 4645.
4645	Light grey	4½ ft.	30-1-21w2	33.9	Good	11.5	Fine grained and plastic.
ROCKGLEN AREA							
3065	Light grey	4 + ft.	SE.-22-2-30w2	31.5	Good	9.5	Total depth not obtained, Dippons farm.
3066	Light cream	4 + ft.	NW.-28-2-30w2	36.0	Good	11.5	Total depth not obtained, Yost farm.
3077	Light grey	12 ft.	S½-13-3-1w3	21.0	Good	5.4	Purple shade under cover. Weathers light.
3078	Light grey	5 ft.	E½-10-3-30w2	32.8	Good	9.4	From near the top of a butte.
3134	Yellowish	12 ft.	SW.-15-3-1w3	29.0	Good	8.2	At "Big Cut". Red-yellow-white, etc.
STRATHALLEN AREA							
3126	Dark grey	2 + ft.	NW.-6-2-2w3	35.2	Good	9.3	Total depth not obtained, some erosion.
3127	Light grey	5 ft.	NW.-36-3-3w3	31.7	Good	10.6	Weathers nearly white, fine grained, Spahr farm.
3129	Dark grey	4 ft.	36-3-3-w3	38.8	Good	12.7	In same deposit as 3127.

Close up of Whitemud Ball and Plastic clays on S.26 - 27; T. 5; R. 3; south of Flintoft, Sask.

TABLE VIII—*Continued*

RAW PROPERTIES OF WILLOWBUNCH CLAYS—Continued

ESTEVAN AREA

4514	Light grey	6 ft.	SE.-15-2-8w2	35.5	A little sticky	13.0	At bridge over Souris river, south of Estevan.
4515	Light grey	4 ft.	NE.-10-2-8w2	34.4	Very good	13.0	On roadway one mile south of above bridge.
4647	Light grey	5 ft.	NE.-10-2-8w2	32.9	Very good	12.4	Larger sample of 4515.
4659	Med. white	4 ft.	SE.-15-2-8w2	26.7	A little short	10.2	A plastic sandy clay below 4660.
4660	Grey and dark	6 ft.	SE.-15-2-8w2	40.5		18.3	Plastic, a large sample of 4514.

GOODWATER AREA

4661	Grey sandy	4 ft.	-24-6-13w2	30.3	Fairly good	8.5	At valley, three miles west of Halbrite.
4711	Brownish	6 ft.	SE.-26-5-11w2	20.5	A little sticky	3.7	East of Goodwater..

TABLE IX

BURNED PROPERTIES OF WILLOWBUNCH CLAYS
PER-CENT FIRE SHRINKAGE AND ABSORPTION

Fired at Cone	WILLOWBUNCH AREA											BONNEAU LAKE AREA		
	Clay 2822	2832	2835	2837	2839	2844	2845	2848	4108	4109	4110	2859	4111	4112
010	*0.6 shk. 17.1 abs.	* 0.2 14.9	0.0 18.7	0.6 19.5	0.6 16.7	0.5 23.3	0.7 17.6	0.3 14.7	....	....	....	2.4 17.1	....	....
07	3.9 shk. 14.8 abs.	0.1 14.8	1.0 17.0	2.2 17.3	2.2 14.6	2.5 19.1	1.9 14.8	1.9 12.0	....	....	....	3.8 14.5	....	....
04	7.3 shk. 12.3 abs.	0.4 14.4	1.59 15.5	3.2 12.3	3.4 11.3	3.4 17.3	3.7 11.8	2.4 11.1	5.3 13.66	3.2 10.9	4.1 8.7	5.4 11.9	1.8 11.4	2.5 11.8
02	9.3 11.0	0.5 13.7	2.9 13.0	4.8 10.7	5.3 8.1	6.4 12.3	6.2 8.0	4.9 5.6	....	....	....	5.7 7.2	....	....
1	10.1 10.8	1.3 12.6	3.4 12.5	5.9 9.1	6.7 5.4	7.8 10.2	6.8 6.1	5.9 4.3	7.8 6.68	5.2 8.3	5.4 6.7	7.3 5.0	3.5 9.2	2.2 12.1
3	11.2 9.6	1.3 10.9	3.9 10.7	6.1 7.2	7.4 3.9	8.8 7.6	7.2 5.2	6.3 3.4	10.9 0.6	7.6 3.5	6.6 4.14	8.9 4.9	5.5 5.4	3.9 10.6
5	15.0 5.8	1.5 10.1	6.8 5.0	9.9 4.7	7.6 0.2	11.7 0.0	8.7 0.0	6.7 0.6	11.6 0.5	9.5 0.2	8.9	9.1 1.9	9.0 0.2	3.4 9.4
7	....	....	....	....	....	....	....	....	11.2 1.4	9.7 0.0	9.4	....	8.9 0.0	3.6 8.7
8	....	....	....	....	....	....	....	....	9.8 1.1	8.9 0.3	9.2 0.0	....	6.6 0.1	3.7 7.7
10	....	....	....	....	....	....	....	....	9.7 1.0	8.5 0.2	9.7 0.2	....	6.1 0.5	3.7 8.0

*—Expansion

TABLE IX—*Continued*

BURNED PROPERTIES OF WILLOWBUNCH CLAYS
PER-CENT FIRE SHRINKAGE AND ABSORPTION—Continued

Fired at Cone	Harptree Area								Big Muddy Lake Area			Lower Big Muddy Valley Area						
	3018	3019	3020	3023	3025	3030	3031	3124	3061	3062	3063	2747	2748	2749	2750	3120	4644	4645
010	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.1	0.8
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.2	16.0
07	5.5 shk.	.....	2.7	.....	.....	0.8	.....	.....	.....	2.9	2.8	.....	.....	.....	.....	2.0	*0.1	1.2
	8.9 abs.	.....	10.2	.....	.....	16.2	.....	.....	.....	13.3	12.8	.....	.....	.....	.....	11.2	18.2	13.0
04	7.3 shk.	.....	2.9	.....	.....	4.7	.....	.....	.....	6.0	6.2	3.2	3.5	1.5	.....	2.6	.....	3.7
	6.2 abs.	.....	9.1	.....	.....	8.4	.....	.....	.....	8.9	6.8	13.0	13.5	15.9	.....	8.8	.....	11.3
02	8.0 shk.	1.1	4.1	5.9	1.2	7.2	2.4	0.0	0.4	6.1	6.7	5.4	5.6	2.9	1.7	5.2	*0.2	.....
	3.2 abs.	12.3	8.8	8.6	12.4	4.2	6.0	14.8	15.0	8.4	5.9	8.5	8.9	12.6	11.7	2.9	18.2	.....
2	9.5 shk.	1.5	4.3	8.0	1.4	7.9	2.6	0.9	0.5	6.5	6.9	6.6	7.4	4.3	2.5	3.9	*0.2	4.2
	0.2 abs.	11.3	0.1	6.3	11.9	2.1	5.8	13.7	15.2	7.3	5.5	5.9	5.2	10.3	9.7	1.4	18.0	7.1
4	9.5 shk.	3.8	5.0	8.5	2.7	.....	4.8	3.3	0.7	8.2	8.4	7.9	9.2	7.1	2.5	3.8	0.1	5.0
	0.0 abs.	6.1	0.0	1.3	4.7	.....	2.7	8.2	14.2	3.6	1.6	0.5	0.2	4.0	6.1	1.4	17.1	6.3
6	10.1 shk.	5.2	5.3	.....	3.8	.....	5.3	3.4	1.8	8.9	9.9	7.9	9.5	7.9	3.7	over-	0.2	5.6
	0.0 abs.	4.6	.....	0.2	4.5	.....	2.4	7.3	11.6	0.7	0.2	0.5	0.2	2.7	5.6	fired	16.4	4.8
7	..... shk.	.....	.....	.....	.....	8.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	..... abs.	.....	.....	.....	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	..... shk.	6.0	.....	.....	3.9	.....	.....	5.0	2.0	.....	.....	8.1	9.1	7.9	3.9	.....	0.4	5.8
	..... abs.	1.9	.....	.....	2.6	.....	1.3	4.9	7.8	.....	.....	0.3	0.0	0.0	4.5	.....	15.4	3.2
9	..... shk.	5.9	.....	8.1	3.9	.....	6.2	5.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	..... abs.	1.0	.....	0.1	1.9	.....	0.5	4.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	..... shk.	.....	.....	.....	.....	.....	.....	.....	2.3	.....	.....	.....	.....	.....	3.9	.....	1.5	.....
	..... abs.	.....	.....	.....	.....	.....	.....	.....	5.5	.....	.....	.....	.....	.....	4.3	.....	14.4	.....

*—Expansion

TABLE IX—*Continued*

BURNED PROPERTIES OF WILLOWBUNCH CLAYS
PER-CENT FIRE SHRINKAGE AND ABSORPTION—Continued

Fired at Cone	Rockglen Area					Strathallen Area			Estevan Area					Goodwater Area	
	3065	3066	3077	3078	3134	3126	3127	3129	4514	4515	4647	4659	4660	4661	4711
010	....	....	....	..... 16.7	....	*0.1 18.6	....	....	1.0 12.2	Missing	0.0 14.3	–0.9 shk. 16.7 abs.	0.5 13.4	0.0 17.6	..... 14.0
07	0.7 shk. 15.0 abs.	0.8 15.3	....	2.8 12.6	1.9 15.2	2.1 15.2	1.2 13.8	....	3.5 9.2	3.6 10.6	1.4 10.9	–0.4 shk. 15.4 abs.	3.1 7.0	1.4 14.8	..... 14.0
04	2.0 shk. 12.7 abs.	3.6 13.0	....	5.1 8.3	3.6 12.3	4.0 12.4	2.5 11.7	....	4.4 6.1	5.7 ?	2.7 8.6	0.0 shk. 15.3 abs.	....	..... 11.4	..... 12.6
02	5.1 shk. 6.5 abs.	7.5 4.2	–0.2 shk. 14.2 abs.	5.8 6.6	5.5 9.2	5.8 8.7	2.8 10.9	4.8 13.0	4.6 4.5	5.4 3.2	3.9 5.6	0.7 shk. 14.4 abs.	Missing	4.0 9.3	..... 10.4
1	....	....	....	....	....	....	....	....	5.8 2.2	6.9	4.8 3.4	0.3 shk. 13.8 abs.	....	4.5 8.1	..... 10.0
2	5.8 shk. 4.7 abs.	8.6 0.2	0.0 shk. 12.5 abs.	7.7 3.0	8.2 3.3	9.0 1.9	5.5 5.9	7.7 8.0	..... Bloated	..... ?	....	0.4 shk. 13.3 abs.	5.0 0.0	4.3 7.9	....
4	7.5 shk. 0.8 abs.	9.5 0.0	0.4 shk. 12.9 abs.	8.6 0.0	9.4 0.1	8.4 0.1	7.6 2.2	Missing	Bloated	7.3 0.0	6.0 0.0	0.7 shk. 11.9 abs.	....	4.9 6.5	..... 8.5
6	8.3 shk. 0.1 abs.	9.5 0.0	0.5 shk. 12.2 abs.	....	9.1 0.0	....	7.9 0.8	Missing	....	....	....	1.0 shk. 11.3 abs.	Bloated	5.7 1.6	..... 7.1
8	....	....	0.5 shk. 11.9 abs.	....	....	....	....	9.0 3.8	....	....	7.5 0.0	1.1 shk. 8.1 abs.	....	6.0 1.5	..... 5.7
10	....	....	0.6 shk. 11.0 abs.	....	....	....	....	9.0 2.8	....	....	12.9 0.0	1.2 shk. 1.7 abs.	....	6.9 0.0	..... 4.4

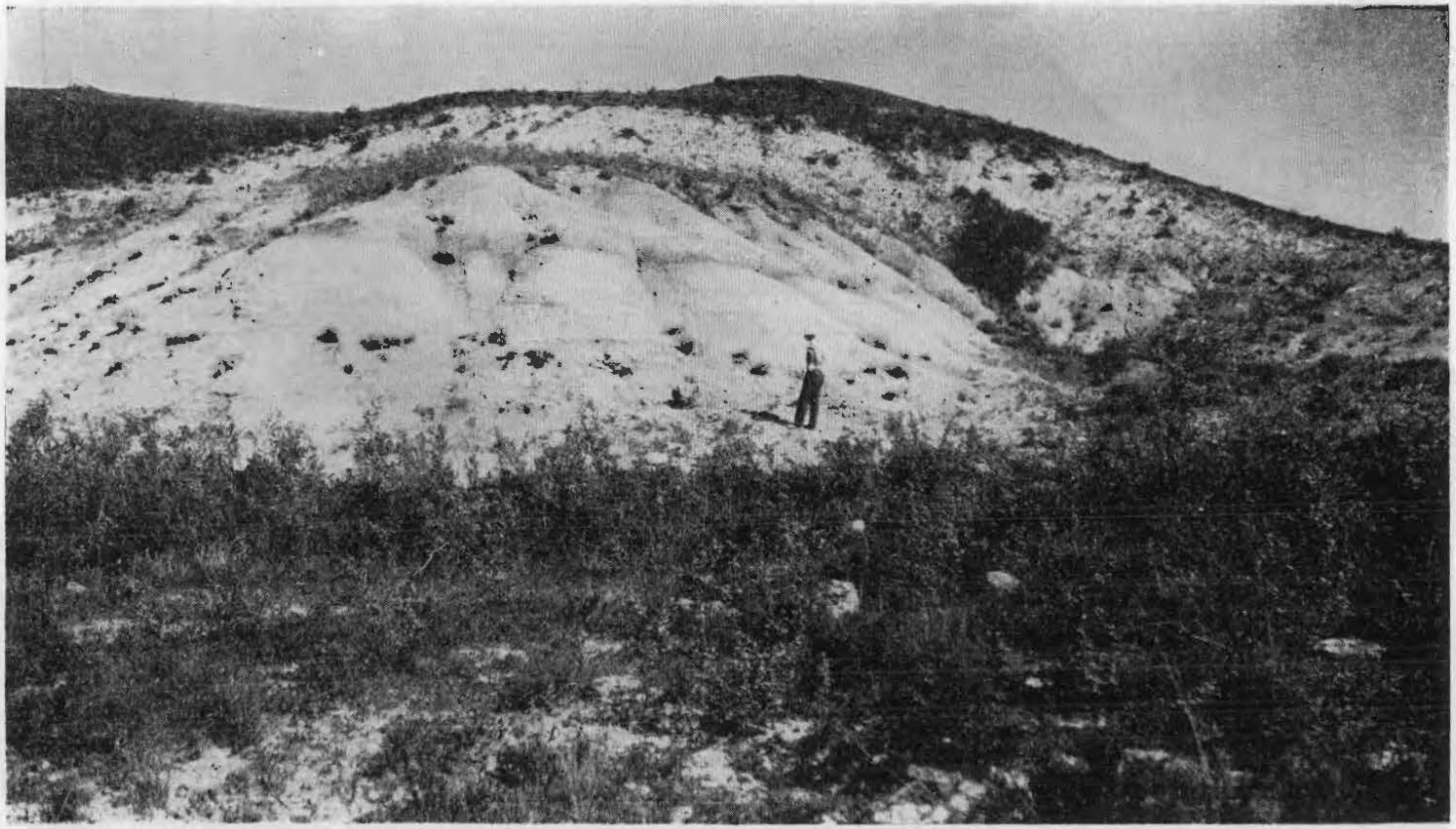
*—Expansion

TABLE X

CORRELATION OF PROPERTIES OF WILLOWBUNCH CLAYS.

No.	Raw Colour	Plastic or Sandy	H_2O of Plty.	Dry Shk.	Steel Hard	Blue-stone	o.o. Abs. at cone
2822	Dark lead grey	Plastic	35.0	10.8	07	None	10+
2832	Grey to choc.	Plastic	28.9	10.1	02	None	10+
2835	Chocolate	Plastic	33.1	8.7	04	None	10+
2837	Black	Plastic	36.3	9.6	07	5	5+
2839	Lead grey	Plastic	33.4	10.0	04	3	*5
2844	Deep chocolate	Plastic	42.6	10.9	010	5	*5
2845	Light grey	Plastic	33.8	9.9	07	3	*5
2848	Med. grey and darker	Plastic	32.4	10.6	010	1	*5+
4108	Black	Plastic	41.2	10.6	.....	04	10+
4109	Light Chocolate	Plastic	31.8	8.8	.....	1	7
4110	Light grey	Plastic	32.8	10.0	.....	1	9
2859	Black	Plastic	38.4	13.1	010	3	.....
4111	Light shade	Semi-sandy	26.8	6.4	.....	1	7
4112	Dark lead grey	.....	31.2	11.2	.....	None	10+
3018	Black	Plastic	38.0	14.2	07	4	4
3019	Grey, light	Semi-sandy	26.3	7.7	02	4	10+
3020	Dark shades	Plastic	34.8	14.0	07	2	3
3023	Dark shades	Plastic	36.3	12.7	02	4	10+
3025	Grey	Semi-sandy	26.1	8.3	02	None	10+
3030	Medium grey	Semi-sandy	35.8	11.6	04	2	6
3031	Light grey	Semi-sandy	34.6	7.7	02	4	10+
3124	Light grey	Semi-sandy	23.0	6.6	02	None	10+
3061	Cream-Buff	Sandy	24.2	5.4	8	None	10+
3062	Nearly white	Plastic	35.5	10.9	07	6	10 ?
3063	Cream white	Plastic	28.8	7.2	07	6	8 ?
2747	Very dark brown	Plastic	35.9	13.6	04 –	None	8+
2748	Dark grey	Plastic	36.4	12.4	04 –	4	8
2749	Brown	Semi-sandy	17.8	9.2	04 –	8	8
2750	Nearly black	Semi-sandy	28.3	10.8	02	None	10+
3120	Dark grey	Semi-sandy	28.8	9.6	07 –	02	6 –
4644	Grey white	Sandy	20.4	4.0	8	None	10+
4645	Yellowish white	Plastic	33.9	11.5	06	6	10+
3065	Light grey	Plastic	31.5	9.5	02	6	4+
3066	Light grey	Plastic	36.0	11.5	04	6	4
3076	Medium grey	Plastic	30.7	8.2	02	6	6+
3078	Light cream	Plastic	32.8	9.4	07	4	4
3134	Yellowish	Plastic	29.0	8.2	07 –	2	6
3126	Dark grey	Plastic	35.2	9.3	010	2	5
3127	Light grey	Plastic	31.7	10.6	07 –	4	10
3129	Dark grey	Plastic	39.0	12.7	02	4	10+
4514	Grey	Plastic	35.4	13.0	04	6	?
4515	Grey	Plastic	34.2	13.0	07	6	?
4647	Grey	Plastic	33.0	12.4	010	3	5
4660	Greyish-yellow	Plastic	40.5	17.8	06	3	3
4650	Yellowish-grey	Plastic	26.7	10.3	010	3	10+
4661	Greyish	Plastic	30.1	8.6	04	5	10+
4711	Brownish	Plastic	20.5	?	02	7	10+

* Overfired.



An exposure of Willowbunch clays on S. 22 - T. 5 - R. 28 - W3rd, west of Willowbunch, Sask.

WHITEMUD FORMATION — CYPRESS HILLS AREA

GENERAL COMMENT

The Whitemud clays in southern Saskatchewan were noted and referred to as the white band by McConnell in 1885; he did not, however, make any reference to their possible future importance. It remained for Davis in 1918 to propose the formational name "Whitemud" which has now become the accepted name. While Davis noted that there were both plastic and sandy beds ranging in colour from white to dark shades, he did not subdivide the formation into zones as was later done by other geologists who worked in the same area, particularly McLearn, Dyer, 1927, McLearn, 1928, Fraser et al, 1935 and Furnival, 1946.

McLearn in 1927, divided the formation into four zones as follows:

(4) Dark shale zone.

(3) White clay zone.

(2) Brown shale zone.

(1) White sandy clay zone.

More recently Furnival (8), as a result of his detailed and extensive work in the Cypress Hills area found sufficient evidence to warrant a revision of the above four zones, and has proposed and used the name Battle for that of the No. 4 zone. In substantiation of the change he refers to the wide differences of the materials in the Battle of those of zones 1, 2, and 3, the former consisting of dark brown to black and greenish grey shales, bentonitic shale, bentonite, silts and argillaceous sands. Attention is drawn to the absence of kaolinization in the Battle, whereas it is common to the three lower zones. Furthermore, the Battle formation shows a sharp change in conditions of sedimentation to those of the Whitemud. He also refers to having only noted bentonite in the Whitemud formation near the west end of his map area while on the other hand the Battle beds include a relatively high proportion of bentonite and bentonitic shales, as well as certain beds of possible volcanic origin.

The Battle formation has been divided by Furnival into two members. The lower one consists of bentonitic weathering dark shales (which in some instances carry beds up to 1 foot thick of siliceous material of possible volcanic origin) in thicknesses ranging from 5 to 30 feet. In all cases the beds were conformable with the underlying Whitemud. The upper member of the formation is of a distinctly greenish shade; there are included beds of olive-green bentonite, greenish shale, silts and sands. In general its upper surface, was found to be unconformable with certain coarse basal sandstones originally called the Lower Ravenscrag. These sandstones have recently been renamed the Frenchman by Furnival, thus leaving the previously named Upper Ravenscrag (14) to now become known as the Ravenscrag. The new formational names now assigned are shown to be warranted in that the Frenchman formation consists very largely of massive or coarsely cross bedded sandstones with little or no coal, in sharp contrast to the Ravenscrag which carries thin beds of silts, fine-grained sands, shales, and numerous coal beds and thin lignitic zones.

To return to the Whitemud zones, the No. 1, or lowest zone is of variable thickness, usually less than 40 feet, and consists largely of partly kaolinized feldspathic fine sandstone, composed largely of grains of quartz, feldspar in various degrees of alteration, plus a matrix of white powdery clay (kaolin). The grain size of the included materials is quite variable from place to place, as is the percentage of kaolin, which in some cases is quite low and in others up to 50 or more per cent.; the variations in same may be noted in the several beds vertically or, more gradually, in lateral direction. Thin carbonaceous streaks occur in places, plus the remains of tap roots near the top of the beds. Cross bedding is not uncommon to some of the sections. The colour varies from a pale yellowish green to white, depending largely on the degree of kaolinization, though there are some variations. For the most part the clay portions when recovered from the sands of this zone in the western area usually fire to a blue-stone grey, while that from deposits in the easterly areas for the most part burn to white or light shades.

The No. 2 zone differs from the No .1 in that it contains dark carboniferous bands of shale and in some places thin beds of lignite are present. In addition to the dark shales and lignite, Furnival reports the presence of kaolinized, feldspathic, fine to coarse-grained, light grey to white clay and shale, some of which are refractory, while the carbonaceous beds are non-refractory. Fossil tap roots are also present in these beds. The thickness of this zone varies from a few inches up to 22 feet.

The No. 3 zone, that just above the dark carbonaceous beds, contains some of the more important clays of the province; those in the Cypress Hills area have long been used at the base material for yellow ware, stoneware and sewerpipe manufacture at Medicine Hat, Alberta. In general the beds are somewhat irregular in thickness, and lateral variation in the beds from place to place to the extent that individual beds are difficult to trace, is common. The colours of these clays range from white to pale blue, pale green, and sometimes, due to iron stain, yellowish shades. In general the clays are only semi-refractory due in part to the presence of semi-or-unaltered feldspar.

YELLOW WARE — STONEWARE TYPE

These clays occur in the general area of the Cypress Hills near the south-west corner of the province, more especially near Eastend, Knollys and Ravenscrag where prominent outcrops may be seen along the valley sides of the Frenchman River. They have been worked by open pit methods since the early part of the present century as a source of supply for the production of yellow ware, stoneware and sewerpipe at Medicine Hat. For those purposes there are two types of clay, those of zone 1, the white kaolinized sandy clays, and those of zone 3, the white or light coloured plastic clays of the Whitemud. It is not uncommon to find this zone of variable thicknesses or even absent in some places due to erosion. The variation in thickness of the plastic zone plus other conditions, such as the amount of overburden to be removed, have greatly influenced the selection of deposits for development during past years. Naturally those containing the maximum amount of plastic clay in relation to the overburden, and the minimum hauling distance to rail have been worked, so that at present there are few known remaining deposits from which clay can be taken as cheaply as in the past. For the most part it will be necessary to remove greater depths of overburden, haul from greater distances or resort to mining. While there is much to commend the latter method of recovery, it must be borne in mind that costs will be somewhat higher than for open pit working, particularly due to the considerable timbering necessary to take care of the poor roof conditions, where shale is the overlying bed.

While the whitemud in the area under discussion corresponds geologically with those further east near Fir Mountain, Flintoft, Willows, and other areas, they are not the same in type or for ceramic uses. Those in the west in the Cypress Hills area are not so pure, and are not as refractory as those further east, nor do they burn as white or as free of colour. These conditions are not only true of the plastic white clays in the west but are also quite true of the clay or kaolin portion recovered through the washing of the kaolinized sandy white clays of the same area; the latter usually burn to cream shades rather than white, and, some even bluestone in the general range of cone 10. In the raw state, some of the clays in the west are whiter than many of those in the east.

In general, the zone 3 plastic stoneware clay must be blended with a portion of the zone 1 kaolinized sandy clay in order that the shrinkage may be reduced and controlled for various kinds of ware, and blending is also used to alter the temperature of firing. That is, the same clay is used for the production of both yellow ware and stoneware, and in the latter case the firing temperature to best suit the body and glaze is several cones higher than for the yellow ware. If the sandy clay is not added, then the stoneware body becomes bluestoned and overfired before the temperature necessary to the melting and maturing of the glaze is reached. There are still other reasons why it is desirable to add the sandy clay to the plastic, the more important being better and faster rates of filtering and casting. The plastic clay is very fine grained and unless opened up by the coarser grained sandy clay, would pack so dense on the filter press cloths that a proper cake could not be produced, and the same general condition would occur in the casting molds.

It should not be assumed that the plastic clay is of low grade or quality such that it requires special treatment. It is not defective in its properties; in fact it is of higher qualities than certain clays which have long been used in other countries for stoneware manufacture. While it used to be common practice to select and depend upon a single clay for yellow ware, stoneware and other kindred lines, such is not the case at present, in that it has been found better to blend two or more clays of different properties, and by so doing there is possible the variation and control of the raw and pyrometric physical properties best suited to any one or more products.

In so far as quantities are concerned, due to erosion near the end of the Whitemud period and other conditions, the amount of the plastic stoneware clay available is far less than that of the sandy clay of zone 1. The former clay should therefore be more generally employed for the lighter or pottery types of ware, with the maximum amount of the sandy clay being used for the heavier clay products. Blends of those clays in zone 2 and the Battle with the sandy clay of zone 1 offer possibilities for investigation regarding the conservation of the white plastic clay. At present and for years past, the clays of zone 2 and the Battle have been discarded with the overburden material as being useless. From past tests these unused clays were found to have undesirably high drying shrinkage, but on the other hand the burning shrinkages were very low, a favourable condition indeed. Therefore, if through blending with the sandy clay the unburned shrinkage could be reduced, then there would be possibilities of using those clays which are now wasted.

In the following tables XI and XII there is presented data regarding the raw and burned properties of a limited number of the Whitemud clays which occur in the Cypress Hills area, more in particular those from near Eastend and Knollys. As may be noted from the data presented, there are variations in the properties of the Cypress Hills Whitemud clays from place to place, though in general they run fairly close to type, to the extent that through blending of the plastic with the more sandy clays it is possible to maintain mixtures of uniform quality. As an example of the variations in the properties of widely used stoneware clays in

the United States, a few of the extremes are presented to show that the variation in the Saskatchewan clays of the same type are well within the limits. The general averages of the former clays are: water of plasticity 18 to 38 per cent. (in most cases above the average of these two figures), drying shrinkage on the dry basis ranging from 5 to 15 per cent. with 8 as a fair average, and modulus of rupture averaging about 250 lbs. per square inch for the raw clay. A fair average of burning shrinkage is about 10 per cent. The absorption naturally varies from near zero in vitrified stoneware to as high as 10 per cent. in some yellow wares, though lower absorption percentages in the latter case to be desired.

These clays can definitely be classed a being of major importance to the ceramic industrial development of the province, in that from them there may be made a wide variety of useful and necessary wares. Among the more important are those wares for which they are now being used, yellow wares, stoneware, artware, sewerpipe and wall coping, to which there may be added through the selection of certain beds, chemical stoneware, terra-cotta, face brick, glazed and enamelled brick and tile, structural and floor tile, fire proofiing, some lines of sanitary ware, stove lining and other lower grade refractories. It is not to be expected that all of the above listed products can be successfully produced, since there may be local conditions, such as costs, markets, and distance to same which might make it unwise to undertake the manufacture of some of the items mentioned. There may be in the future, as in the past, economic reasons for shipping some of the clays to other points for manufacture.

Outcrop exposure of the sandy and plastic Whitemuds near the west end of Willowbunch Lake.

Sandy Whitemud clays exposed on the east wall of Frenchman River valley near the Whitemud P.O., south of Dollard, Sask.

TABLE XI

RAW PROPERTIES OF WHITEMUD YELLOW WARE — STONEWARE CLAYS.

EASTEND-CYPRESS HILLS AREA

Sample No.	Location	Raw Colour	Thickness Sampled	Overburden	% Water Plasticity	% Drying Shrinkage	General Remarks
431	7 & 8-7-21w3	White	5′—0″	10—20 ft.	26.0	6.0	This clay reported to dry safely.
432	7 & 8-7-21w3	Purple grey	2′—0″	10—20 ft.	23.0	8.3	Contains fine-grained iron concretions.
433	7 & 8-7-21w3	White	6′—0″	10—20 ft.	24.0	5.0	This clay and the two above occur together and have been widely used.
434	36-6-22w3	Light Grey	6′—0″	?	25.0	6.0	This clay and 436 occur together and used
436	36-6-22w3	Dark grey	?	?	25.0	7.0	for pottery and sewer pipe since 1916.
437	25-6-22w3	Very light grey	8′—0″	?	24.0	6.0	This and the next two clays have long
438	25-6-22w3	Greyish white	5′—0″	10—30 ft.	25.0	7.0	been used for yellow ware, stone-ware and
440	25-6-22-w3	White	4′—0″	10—30 ft.	26.0	8.6	sewer pipe.
C25	NW.25-6-23w3	Pale grey green,	3′—5″	10—30 ft.	27.0	8.5	Working properites reported as good.
C8	SE.29-6-22w3	Not given	5′—3″	10—30 ft.	26.0	6.5	Good plasticity.
C30	SE.29-6-22w3	Pale greenish	2′—9″	10—30 ft.	26.5	7.5	Fair plasticity.
W1646	NW.36-6-22w3	White	5′—0″	10—30 ft.	22.0	5.8	Short, working properties rather poor.
W1678	NE.15-6-22w3	White	6′—0″	10—30 ft.	20.7	5.0	Short, working properties rather poor.
W1676	NE.15-6-23w3	Brown	2′—6″	10—30 ft.	30.7	8.8	Plasticity very good.
14	SE.17-6-22w3	Nearly white		?—40 ft.	28.7	9.4	Is very plastic, smooth grained.
4411	SE.17-6-22w3	Nearly white	4′—0″	?—40 ft.	18.9	2.8	More siliceous, occurs just below No. 14
4412	SE.6-7-22w3	Nearly white	6′—0″	10—40 ft.	27.0	6.4	This corresponds closely to No. 14.
4413	SE.6-7-22w3	Nearly white	4′—0″	10—40 ft.	22.5	5.3	This corresponds closely to No. 4411.
4414	SE.8-7-21w3	Purple grey	5′—0″	10—40 ft.	31.4	9.6	Rest on the plastic white beds.
4608	SE.30-6-22w3	Bluish-grey	8′—0″	0—40 ft.	30.3	8.0	A fairly large exposure.

NOTE:— Samples 431—440 inclusive—Davis, N. B., Dept. Mines, Canada, Mines Branch, Rept. 468.
Samples C25—W1676 iuclusive—McLearn, F. H. and McMahon J. F., Geol. Surv. Canada, Sum. Rept. B 1933.
Balance, Ceramic Dept, University Sask.

TABLE XII

BURNED PROPERTIES OF WHITEMUD YELLOW WARE — STONEWARE CLAYS

Fired at Cone	EASTEND—CYPRESS AREA (Percent burned shrinkage and absorption)																			
	Clay No 431	432	433	434	436	437	438	440	C25	C8	C30	W1646	W1678	W1676	14	4411	4412	4413	4414	4608
010	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.7	*0.5	0.0	0.0	1.1	*0.5
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.6	18.4	18.9	16.1	18.2	17.2
07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.8	*0.6	0.1	0.0	....	0.0
			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.8	17.8	17.2	15.9	17.1	17.0
05	White	Dirty	Cream	Creamy	Creamy	Creamy		Dirty	.....	.....	.....	0.0	0.0	2.3	.....	.....	.....	L.	.....	.....
	.....	Cream	Shade	White	White	White	Cream	Cream	.....	.....	.....	13.5	14.5	12.8	.....	.....	.....	Cream	.....	.....
04	White	Dirty	Cream	Creamy	Creamy	Creamy	Cream	Dirty	.....	.....	.....	L.		L.	1.8	0.0	2.1	0.0	.....	5.9
	.....	Cream	Shade	White	White	White		Cream	.....	.....	.....	Cream	White	Buff	11.9	17.4	15.2	14.5	16.6	7.2
02	White	Dirty	Cream	Creamy	Creamy	Creamy	14.6	Dirty	.....	.....	.....	L.	White	L.	2.2	0.0	3.0	0.9	.....	6.9
		Cream	Shade	White	White	White	Cream	Cream	.....	.....	.....	Cream		Buff	10.0	17.2	13.1	13.7	14.9	5.6
1	Cream	Dirty	Cream	Creamy	Creamy	1.6	Cream	Dirty	.....	.....	.....	L.	White	L.	2.9	0.7	5.7	1.9	.....	8.7
		Cream	Shade	White	White	21.7		Cream	.....	.....	.....	Cream		Buff	7.6	16.3	7.9	11.8	10.5	0.6
2	Cream	Dirty	Cream	Creamy	Creamy	Creamy	Cream	Dirty	5.0	4.5	5.0	1.0	White	6.4	.....	.....	.....	L.	.....	.....
		Cream	Shade	White	White	White		Cream	6.7	12.3	4.3	10.7		5.0				Cream		
3	Cream	Dirty	Cream	Creamy	Creamy	Creamy	Grey	3.4	L.		L.		0.7	P.gray	3.8	0.6	6.9	2.4	.....	
		Cream	Shade	White	White	White		.....	Grey	Cream	Drab	Cream	11.5	Buff	7.6	16.0	6.5	10.9	10.5	
4	Cream	Dirty	Cream	Creamy	Creamy	Creamy	Grey	D.	5.5	5.0	7.0				.....	.....	.....	L.		
		Cream	Shade	White	White	White		Grey	4.7	6.5	1.7	?	?	?				Cream		

*—Expansion

TABLE XII—*Continued*

BURNED PROPERTIES OF WHITEMUD YELLOW WARE — STONEWARE CLAYS

Fired at Cone	EASTEND—CYPRESS AREA																			
	Clay No. 431	432	433	434	436	437	438	440	C25	C8	C30	W1646	W1678	W1676	14	4411	4412	4413	4414	4608
5	Cream	Dirty Cream	Cream Shade	6.0 5.4	Creamy White	Creamy White	Grey	4.4	Cream Grey	Cream	Light Drab	?	?	?				L. Cream		
6	Grey	Grey	Grey	Creamy White	Creamy White	Creamy White	Grey	D. Grey	7.5 1.1	6.5 3.9	7.0 0.0	2.0 8.0	0.9 11.5	6.6 4.5	5.1 4.3	1.0 15.3	7.7 4.3	3.0 9.2	..... 9.0	
7	9.0Shk. ..... Abs.	6.7	Grey	Creamy White	Creamy White	6.0 L.grey	Grey	Over fire	Grey	Grey	Drab	Grey Buff	Dirty Buff	Good Buff				L. Grey		
8	....	....	Grey	Creamy White	Creamy White		Grey	....							5.5 2.1	2.3 11.6	9.5 0.0	..... 6.1	..... 8.2	
9	Over fire	Over fire	Over fire	9.0 Grey	2.6 9.3		Over fire	.....										L. Grey		
10	Over fire	Over fire	Over fire	9.0 Grey			Over fire								6.2 1.5	3.6 9.5	9.9 0.0	6.2 2.5	..... 7.6	

WHITEMUD FORMATION — SOUTH CENTRAL AREA

BALL CLAY TYPE — WHITE OR LIGHT BURNING

Geological Comment

This group of the Whitemud clays, while of the same geological age as those in the Cypress Hills area, are as aforementioned, usually different in raw and burned properties. In the raw state they are grey, purple, brownish, chocolate, and some nearly black, and they burn white or at least to very light colours, due to the fact that most of the impurities present are organic. There are some which are stained by iron; these may be of pink, yellowish, or rust shades and do not burn white. The condition of the iron, however, has a strong influence; for instance, where it occurs as small concretions or in oolitic form the raw clay may not be discoloured, though when burned the small iron grains will show as dark specks or spots. In such cases it is often possible by washing and screening or by flotation to remove the iron, though unless the iron is in particle form, such methods will not improve the clay.

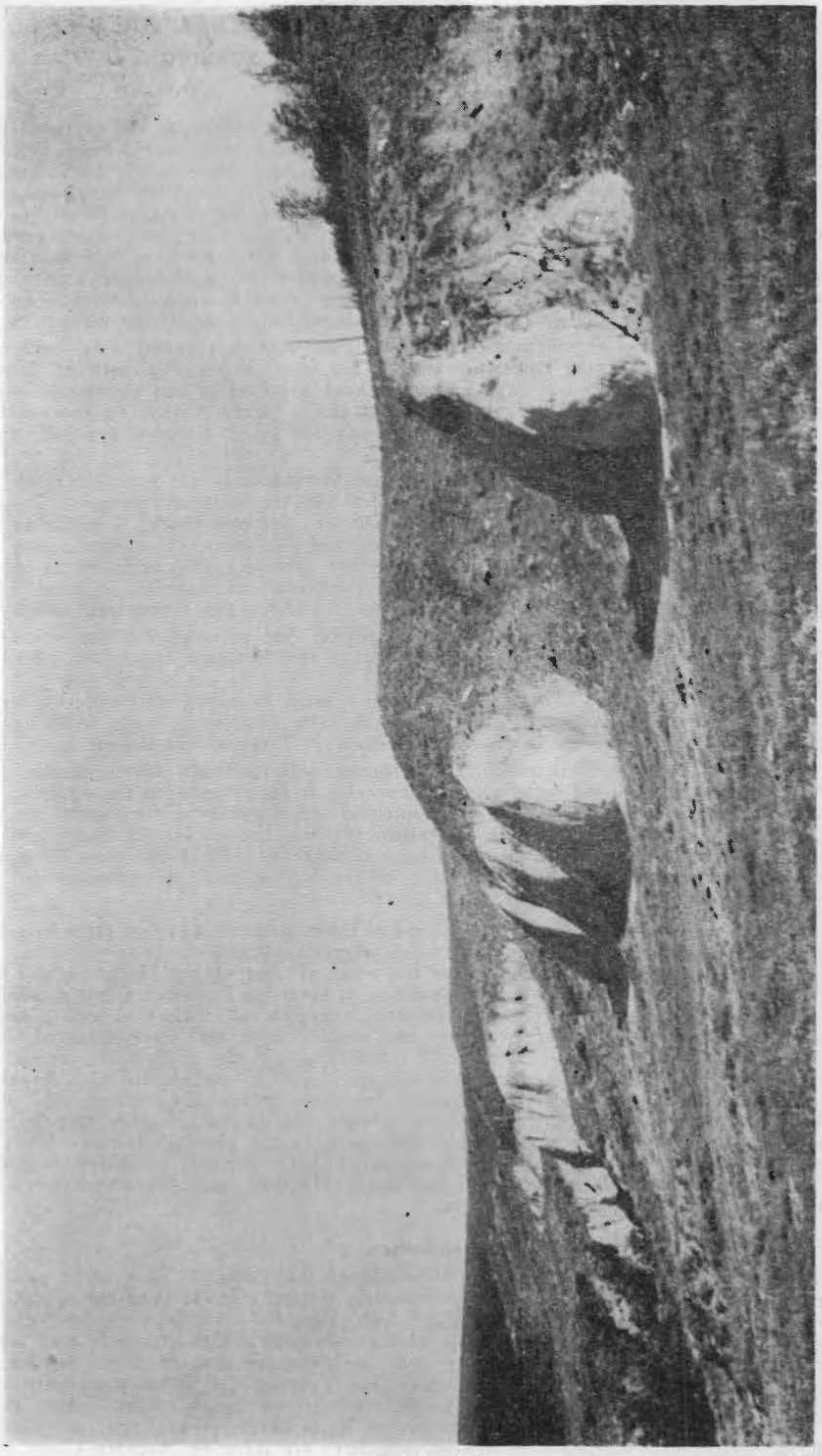
The more easterly Whitemuds in which the ball clays occur are found to be more widely distributed than are those of the stoneware type in the west. In moving eastward from the Cypress Hills area, the stoneware clays are not found to outcrop east of range 19-w3rd, except in a few isolated cases, their absence being due to early periods of erosion which removed large areas of the Whitemuds to the east such that the Bearpaw is exposed at many places.

> To quote Furnival (8) "The Whitemud formation is not everywhere in contact with the overlying Battle formation, but like the Eastend formation, has been subjected to erosion prior to deposition of the post-Battle, Frenchman formation. At many places within the area Whitemud beds are in contact with coarse greenish-brown sands of the Frenchman formation, erosion having removed all of the Battle formation and more or less of the Whitemud—at other places erosion has also removed all of the Whitemud and part of the Eastend formation."
>
> . . . . "During a subsequent erosional period that preceded the deposition of the Cypress Hills formation, beds as low as the Bearpaw formation were removed in places."
>
> Quoting from McLearn (17) "The Whitemud beds were not only subject to erosion in the pre-Ravenscrag interval, but to later erosion as well, for clay deposits of both zones were destroyed by erosion in Tertiary and Recent times."
>
> . . . . "Thus the Whitemud and Ravenscrag, with its Willowbunch member, were removed from all but certain areas favourable to preservation in the southern part of the province. This is why the Whitemud and Ravenscrag formations are now confined to the old and high watershed between the ancient Missouri and Saskatchewan drainage basins, including the high Cypress Hills, Frenchman River, Wood Mountain, and Big Muddy Uplands, to the high Coteau, and possibly also to the synclinal basin along the Souris River."

East from the most easterly outcrops of the Whitemud in the Cypress Hills-Frenchman River areas there is a wide gap of nearly 100 miles where the Whitemud is absent. From there on numerous type outcrops may be noted near the small villages of Fir Mountain and Wood Mountain, then east and northward along the railway in township 5, ranges 3 and 4, south and southeast of Flintoft there are numerous splendid outcrops of both the plastic and the kaolinized sandy Whitemuds. Other exposures are on the north and south sides of Twelve Mile Lake in township 6 near the lower end of the lake. To the north-east from the last mentioned location near the villages of Willows and Readlyn are located the deposits of Whitemuds which have been under development for many years. Clays from this general district have been widely used at Medicine Hat, Alberta, for the manufacture of pottery and sewerpipe, also for a number of years regular shipments of the plastic ball clays from these deposits and others near the west end of Willowbunch Lake were made to whiteware potteries in Ohio, an export market which was finally lost due to the depression years and certain local conditions rather than the quality of the clay.

Distribution

The outcrops near the west end of Willowbunch Lake are the last to be seen until reaching the Big Muddy Valley at a point aproximately sixteen miles west of the upper end of Big Muddy Lake; from there eastward along the deep valley for ten miles there are very good exposures of both the plastic and sandy beds of the Whitemuds. Unfortunately they are low down near the valley floor and are therefore under an excessive amount of overburden, such that open pit working would be practically impossible. This area is the most easterly known major occurrence of the Whitmuds of the white burning type. Small outliers which may be isolated blocks, are found in the valley of the Souris River in the general area of Goodwater and Halbrite. Other more distant showings or exposures are those on Avonlea Creek, others at Claybank in the Dirt Hills, those in the Cactus Hills, small showings near the north end of Lake of the Rivers, also in the Vermilion Hills north of Aquadell, and outcrops ten miles south of Beechy in township 21-ranges 10 and 11-w3rd, plus small findings at a limited number of other places. Those readers of this report who may be further interested in the location of the high grade Saskatchewan clays will find much of interest presented on Map 267A (7).



Whitemud outcrops near Willows, Sask., on S. 4 - T. 8 - R. 29 - W.2nd., on the north side of the Can. Pacific Ry.

Properties

In the following tables XIII, XIV, XV, and XVI, there are presented some of the more important raw and burned properties of a number of the clays of the type under consideration. For other samples reference is made to Worcester, "Twenty-One Saskatchewan Ball clays" (28), and to the Annual Reports, recorded as appendices to this report.

TABLE XIII

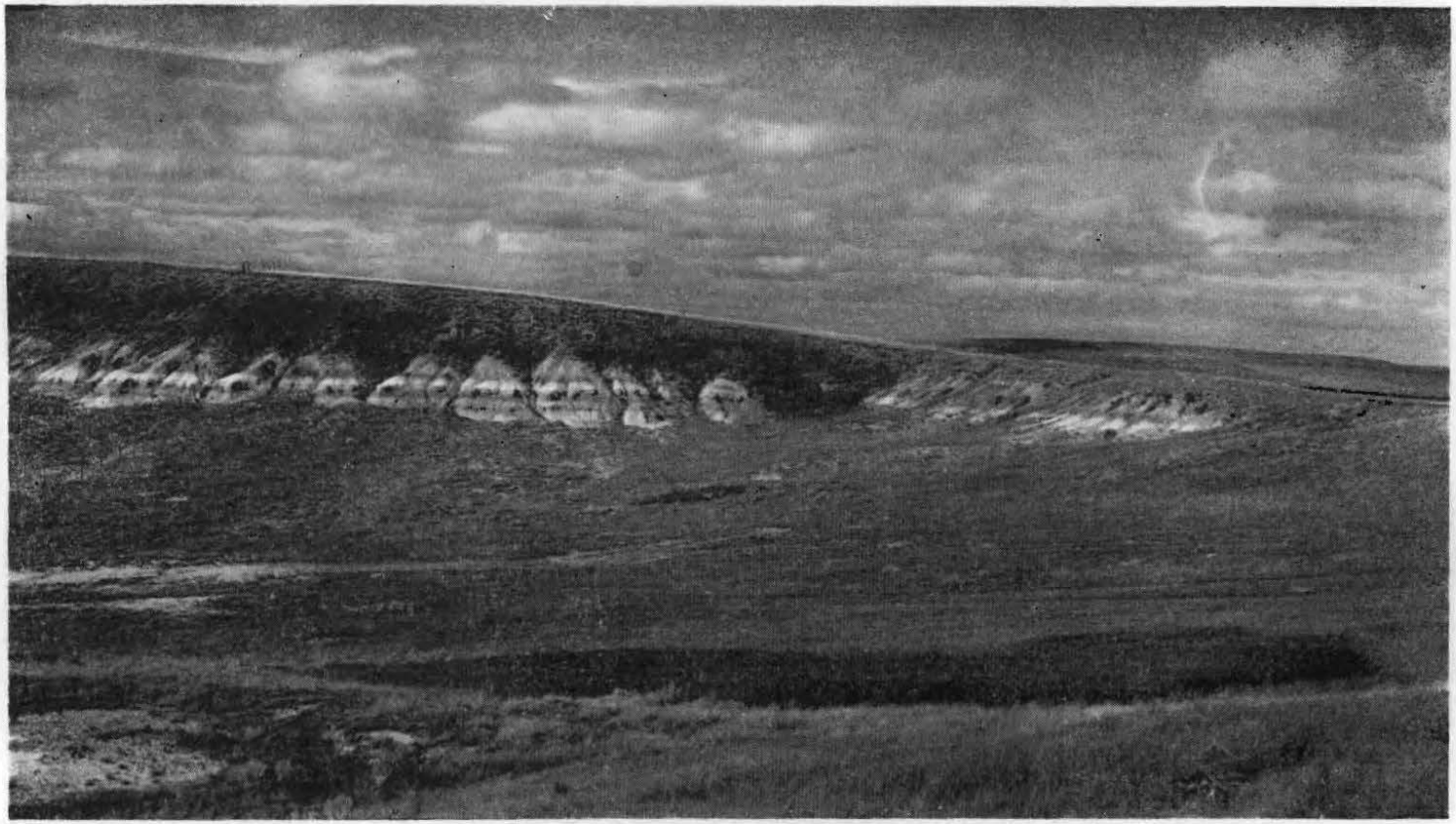
RAW PROPERTIES OF THE WHITEMUD LIGHT-BURNING PLASTIC CLAYS

Sample No.	Location	Raw Colour	Thickness Sampled	Overburden	% Water Plasticity	% Drying Shrinkage	General Remarks
FIR MOUNTAIN AREA							
3137	NE.-15-5-4w3	Chocolate	1′—0″	10—30 ft.	36.4	9.7	Taken from a butte. Is a little too sandy.
3138	NE.-16-5-4w3	Dark grey	1′—0″	10—25 ft.	32.5	8.1	Taken just above 3137, is fairly plastic.
3139	NE.-16-5-4w3	Med. grey	5′—0″	10—20 ft.	30.7	8.3	Taken just above 3138, is fairly plastic.
3140	NE.-16-5-4w3	Rusty grey	6′—0″	10—20 ft.	34.5	9.8	Taken above a band of clay ironstone concretions.
3141	NE.-16-5-4w3	Med. grey	3′—0″	10—20 ft.	36.1	9.7	Taken just above 3140.
30102	NE.-17-5-4w3	Purplish	6′—0″	10—20 ft.	32.5	9.9	
30103	NE.-17-5-4w3	Dk. chocolate	3′—6″	10—20 ft.	35.5	12.9	
FLINTOFT AREA							
3092	NW.-34-5-3w3	Med. grey	6′—0″	10—20 ft.	33.9	9.2	Good drying properties.
3093	NW.-34-5-3w3	Light grey	4′—0″	10—20 ft.	35.3	9.8	1 ft. of lignite between this and 3092.
3095	NW.-34-5-3w3	Purple	3′—0″	10—20 ft.	30.5	8.1	This sample is above 3092 and 3093.
3904	NE.-27-5-3w3	White	3′—0″	10—20 ft.	38.6	8.6	This is the only white ball clay so far found in Saskatchewan.
4425	NE.-27-5-3w3	Brownish	4′—0″	10—20 ft.	34.9	9.4	This sample taken just above 3904.
4426	NE.-27-5-3w3	Lighter shade	5′—0″	10—20 ft.	34.3	9.1	This sample taken just above 4425.
4104	NW.-26-5-3w3	Purplish grey	3′—0″	10—15 ft.	31.2	8.1	This and the next sample were collected
4105	NW.-26-5-3w3	Purplish grey	6′—0″	10—15 ft.	33.4	8.8	one quarter mile south of three preceding.
WILLOWS—READLYN AREA.							
2622	NE.-1-8-29w2	Purplish grey	5′ Approx.	10—15 ft.	34.3	9.9	This deposit has been under development for years.
2624	NE.-30-7-28w2	Purplish grey	4′—0″	Mined	38.6	13.6	No shipments since 1930.
2770	SE.-33-7-28w2	Purplish grey	2′—6″	8—15 ft.	33.1	9.6	92 is the new number. Occurs below a thin lignite seam.
4420	SE.-12-8-29w2	Dark grey	10′—0″	10—15 ft.	32.8	10.8	Thin lignite seam above and a clay zone plus concretions below.
4421	NW.-7-8-28w2	Purplish grey	8′—0″	10—15 ft.	32.8	10.2	Occurs just below a thin lignite seam.
2615	SE.-33-7-28w2	Nearly white	10′—0″	0—30 ft.	33.4	10.1	10 is the new number. Occurs twelve ft. below 2,770.

TABLE XIII—*Continued*

BURNED PROPERTIES OF THE WHITEMUD LIGHT BURNING PLASTIC CLAYS

Sample No.	Location	Raw Colour	Thickness Sampled	Overburden	% Water Plasticity	% Drying Shrinkage	General Remarks
VERWOOD—WILLOWBUNCH AREA.							
2767	SW.-12-6-28w2	Very dark	5′—0″	30—40 ft.	39.7	11.4	Raw modulus of rupture 1,008 lbs. 50% clay 50% flint.
4119	SW.-12-6-28w2	Med. grey	3′+	Mined	40.2	15.5	This clay mined and shipped 1925-1932.
1307	SW.-12-6-28w2	Light grey	3′+	Mined	40.3	14.7	From same mine as 4119, though collected in 1944.
2614	S.-6-7-27w2	Light grey	9′—0″	30—40 ft.	34.2	10.1	Raw modulus of rupture 745 lbs.
BIG MUDDY VALLEY AREA.							
3046	SW.-36-3-24w2	Purplish grey	5′—6″	Excessive	47.4	18.9	This clay would have to be mined. There is lignite above it.
3121	NW.-34-3-24w2	Dark grey	3′—0″	Excessive	32.6	8.2	This clay occurs just below 3122.
3122	NW.-34-3-24w2	Med. grey	3′—0″	Excessive	32.7	8.6	This clay occurs just below 3122. A thin seam of white clay.
3910	NW-27-3-24w2	Light grey	2′—6″	Excessive	31.7	9.4	This clay occurs above other ball clays and under lignite.
3912	NW-34-3-24w2	Light grey	5′—0″	Excessive	35.2	10.5	This and the above clays would all have to be mined.
BLUE HILLS—GOODWATER—NEIDPATH							
2728	NW-19-13-25w2	Purplish grey	10′—0″	0—30 ft.	38.9	11.9	This and other local clays are used in compounding refractory bodies.
3115	SE.-18-5-12w2	Light grey	4′—0″	?	27.2	6.7	This bed of clay is at a steep angle. May not be in place.
3116	SE-18-5-12w2	Dark grey	2′—0″	?	28.0	6.8	This bed of clay is at a steep angle. May not be in place.
3110	SW.-13-14-11w3	Light grey	4′—0″	20—+ ft.	34.6	8.2	This clay and No. 3143-44 are closely associated.
3143	SW.-13-14-11w3	Purplish grey	2′—+	20—+ ft.	39.4	13.7	The area will require a thorough investigation in that the conditions are unusual, possibly a fault block.
3144	SW.-13-14-11w3	Light yellowish	5′—+	20—+ ft.	45.0	13.9	



Type exposure of Whitemud beds with overburden of Ravenscrag, south of Flintoft, Sask. Dark spots at base of white band are iron bearing concentrations.

TABLE XIV

BURNED PROPERTIES OF THE WHITEMUD LIGHT BURNING PLASTIC CLAYS

(Percentage fire shrinkage and absorption)

Fired at Cone		FIR MOUNTAIN AREA						
		Clay 3137	3138	3139	3140	3141	30102	30103
010		.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....
07	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....
04	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....
02	.....	5.5 shk.	4.5	4.8	5.9	4.8	5.6	6.3
		18.7 abs.	18.7	16.1	13.9	17.3	12.8	12.7
1	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....
2	.....	7.0	4.9	6.6	9.2	7.6	7.0	8.9
		14.0	15.4	12.7	9.6	10.8	10.7	8.3
3	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....
4	.....	7.9	10.3	10.4	10.5	11.0	9.2	11.3
		13.0	8.4	7.5	3.1	5.4	7.4	0.1
6	.....	7.9	10.4	10.6	.....	11.0	9.5	11.4
		12.7	8.1	6.5	.....	4.1	6.3	0.0
7	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....
8	.....	8.6	10.4	11.0	.....	11.0	10.1	11.5
		10.6	7.3	6.5	.....	4.0	5.6	0.0
9	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....
10	.....	8.7	10.4	11.0	.....	11.4	10.3	11.6
		10.5	6.9	4.5	.....	2.3	4.5	0.0
12	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....
14	.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....

TABLE XIV

BURNED PROPERTIES OF THE WHITEMUD LIGHT BURNING PLASTIC CLAYS—Continued

(Percentage fire shrinkage and absorption)

Fired at Cone		FLINTOFT AREA							
		Clay 3092	3093	3095	3904	4425	4426	4104	4105
010		.....	.....	.....	.....	1.8	.....	.....	.....
		.....	.....	.....	.....	22.0	20.7	.....	.....
07		.....	.....	.....	.....	2.4	.....	.....	.....
		.....	.....	.....	.....	23.0	19.8	.....	.....
04		.....	.....	.....	.....	3.1	.....	3.4	5.7
		.....	.....	.....	.....	19.5	19.8	14.7	13.2
02		2.9	3.7	4.3	4.0	3.8	.....	.....	.....
		16.0	15.6	15.2	26.4	18.4	17.5	.....	.....
1		.....	.....	.....	.....	7.2	.....	5.5	6.6
		.....	.....	.....	.....	13.5	16.7	11.9	13.1
2		3.9	4.4	5.2	4.4	.....	.....	.....	.....
		16.0	14.0	14.6	22.7	.....	.....	.....	.....
3		.....	.....	.....	.....	7.3	.....	5.9	9.4
		.....	.....	.....	.....	12.3	14.8	11.8	8.7
4		5.2	5.5	7.8	7.6	.....	.....	.....	.....
		13.2	12.3	12.5	19.5	.....	.....	.....	.....
6		5.8	6.0	8.3	8.7	8.3	.....	.....	.....
		10.7	10.4	11.4	14.0	10.7	8.4	.....	.....
7		.....	.....	.....	.....	.....	.....	7.2	.....
		.....	.....	.....	.....	.....	.....	8.1	4.6
8		6.3	7.2	8.9	9.8	.....	.....	.....	.....
		9.2	8.8	8.3	12.4	9.5	6.8	.....	.....
9		.....	.....	.....	.....	.....	.....	.....	.....
		.....	.....	.....	.....	.....	.....	.....	4.6
10		6.5	7.4	9.5	11.0	.....	.....	7.9	.....
		8.5	8.0	7.7	9.1	8.4	5.6	7.2	3.7
12		.....	.....	.....	11.2	.....	.....	.....	.....
		.....	.....	.....	9.1	.....	.....	.....	.....
14		.....	.....	.....	12.6	.....	.....	.....	.....
		.....	.....	.....	6.4	.....	.....	.....	.....

TABLE XIV

BURNED PROPERTIES OF THE WHITEMUD LIGHT BURNING PLASTIC CLAYS—Continued

(Percentage fire shrinkage and absorption)

Fired at Cone	WILLOWS-READLYN AREA					
	Clay 2622	2624	2770	4420	4421	2615
010	.....	.....	.....	1.2	.....	.....
	.....	.....	.....	17.0	19.3	.....
07	.....	.....	.....	.....	1.1	.....
	.....	.....	.....	16.4	18.2	.....
04	.....	.....	.....	.....	2.9	.....
	.....	.....	.....	14.7	17.6	.....
02	.....	.....	.....	.....	3.6	.....
	.....	.....	.....	13.0	15.9	.....
1	.....	.....	.....	5.7	.....	.....
	.....	.....	.....	.....	11.2	.....
2	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	6.8	.....	.....
	.....	.....	.....	10.6	11.2	.....
4	.....	.....	.....	.....	.....	.....
	5.7	3.2	6.2	.....	.....	5.7
6	9.2	8.9	7.0	.....	.....	7.2
	5.42	2.4	5.3	9.1	9.5	5.7
7	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
8	9.7	8.9	7.2	.....	.....	7.3
	4.1	1.9	3.9	7.3	8.5	5.7
10	9.9	9.2	7.7	.....	7.9	7.9
	3.9	1.9	4.6	5.6	7.7	4.1
12	10.5	9.6	7.8	.....	.....	8.4
	1.6	1.9	2.8	.....	.....	3.0
14	.....	.....	.....	.....	.....	.....
	1.3	1.8	1.6	.....	.....	0.4

TABLE XIV

BURNED PROPERTIES OF THE WHITEMUD LIGHT BURNING PLASTIC CLAYS—Continued

(Percentage fire shrinkage and absorption)

Fired at Cone	VERWOOD-WILLOWBUNCH AREA			
	2767	4119	1307	26150
010	.....	.....	.....	.....
	.....	.....	.....	.....
07	.....	.....	.....	.....
	.....	.....	.....	.....
04	.....	.....	0.0	.....
	.....	11.7	14.4	.....
02	.....	.....	.....	.....
	.....	.....	.....	.....
1	.....	.....	1.8	.....
	.....	8.2	12.7	.....
2	.....	.....	.....	.....
	.....	.....	.....	.....
3	.....	.....	1.8	.....
	.....	7.0	12.7	.....
4	.....	.....	.....	.....
	3.4	.....	.....	3.4
6	8.2	.....	2.4	8.4
	2.0	4.0	11.3	3.2
7	.....	.....	.....	.....
	.....	4.0	.....	.....
8	8.6	.....	4.6	8.7
	1.9	.....	9.3	2.1
10	9.1	.....	4.5	9.1
	1.8	3.9	7.4	2.5
12	9.6	.....	7.5	9.2
	1.6	.....	1.0	0.9
14	.....	.....	9.3	.....
	1.3	.....	0.0	0.5

TABLE XIV

BURNED PROPERTIES OF THE WHITEMUD LIGHT BURNING PLASTIC CLAYS—Continued

(Percentage fire shrinkage and absorption)

Fired at Cone	BIG MUDDY VALLEY AREA				
	3046	3121	3122	3910	3912
010	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
07	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....
04	.....	.....	.....	.....	.....
	.....	.....	.....	10.5	.....
02	6.5	5.6	5.4	.....	.....
	8.7	18.9	17.2	.....	.....
1	.....	.....	.....	.....	.....
	.....	.....	.....	8.9	.....
2	8.6	8.4	8.1	.....	9.4
	4.5	13.7	11.1	.....	8.7
3	.....	.....	.....	.....	.....
	.....	.....	.....	8.1	.....
4	10.4	10.2	8.9	.....	9.6
	1.7	9.5	6.9	.....	7.3
6	10.2	10.2	10.7	.....	10.0
	1.5	9.4	6.5	6.5	6.0
7	.....	.....	.....	.....	.....
	.....	.....	.....	6.1	.....
8	10.7	10.6	10.7	.....	11.0
	0.7	8.3	6.2	5.2	6.0
10	11.0	11.1	11.4	.....	11.2
	0.7	8.0	5.8	4.7	4.6
12	.....	.....	.....	.....	11.0
	.....	.....	.....	.....	4.9
14	.....	.....	.....	.....	2.0
	.....	.....	.....	.....	2.0

TABLE XIV

BURNED PROPERTIES OF THE WHITEMUD LIGHT BURNING PLASTIC CLAYS—Continued

(Percentage fire shrinkage and absorption)

Fired at Cone	BLUE HILLS-GOODWATER-NIEDPATH					
	Clay 2728	3115	3116	3110	3143	3144
010	shk.	.....	.....	.....	.....	.....
	abs.	.....	.....	.....	.....	.....
07	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
04	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
02	.....	4.1	3.5	4.2	4.1	5.9
	.....	17.4	17.1	20.3	15.3	15.5
1	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
2	.....	5.8	5.4	5.6	6.8	8.5
	.....	14.0	14.0	18.0	10.3	10.2
3	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
4	.....	9.9	8.3	11.3	9.1	9.1
	2.7	6.7	10.1	6.3	5.2	9.0
6	9.0	10.2	8.7	12.3	9.2	9.1
	2.3	6.1	8.9	5.6	3.0	8.5
7	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
8	9.6	11.0	8.8	12.4	9.2	9.2
	1.4	5.3	7.7	4.3	2.1	8.3
9	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
10	9.7	11.0	9.3	13.0	9.7	9.2
	1.4	4.9	7.2	3.9	1.2	7.6
12	9.9	.....	.....	.....	.....	.....
	1.3	.....	.....	.....	.....	.....
14	.....	.....	.....	.....	.....	.....
	1.2	.....	.....	.....	.....	.....

TABLE XV

ANALYSIS OF WHITEMUD BALL CLAYS — WILLOWS DISTRICT (28)

Ceramic Dept. No.	2617	2622	2624*	2629*	2611	2619
Chemistry Dept. No.	54/27	55/27	56/27	57/27	70/27	71/27
Loss on ignition	11.66	13.665	13.02	9.16	13.56	12.45
Silica (SiO_2)	56.92	51.285	54.31	65.14	54.49	55.63
Alumina (Al_2O_3)	28.96	32.70	28.77	28.87	28.89	29.36
Titania (TiO_2)	1.02	0.68	0.78	1.05	0.75	0.82
Iron (Fe_2O_3)	0.85	0.69	0.81	0.73	0.79	0.90
Lime (CaO)	0.58	0.78	0.98	Trace	1.08	0.56
Magnesia (MgO)	0.25	0.30	0.65	0.33	0.62	0.35
Alkalis (Na_2O)	0.21	0.43	0.90	0.10	0.02	0.23
Total	100.45	100.53	100.22	100.33	100.20	100.30

*—Unwashed.

Ref. (5)	474	474W
SiO_2	58.28	56.42
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	1.73
CO_2	.10	.17
H_2O	12.02	10.40
	100.74	100.30

TABLE XVI

WASHING TESTS ON TWENTY SASKATCHEWAN BALL CLAYS — ELUTRIATION (28)

No.	% in 200 Mesh	% in No. 1 Can	% in No. 2 Can	% in No. 3 Can	% Total Sands	Clay
2614	5.1	1.1	2.9	10.9	20.0	80.0
2615	5.3	2.5	5.4	8.4	21.6	78.4
2617	3.7	1.0	3.3	5.9	13.9	86.1
2619	5.2	2.0	5.1	8.4	20.7	79.3
2622	3.4	1.0	2.9	7.0	14.3	85.7
2624	5.5	0.8	4.5	8.5	19.3	80.7
2626	14.3	5.4	4.9	10.4	35.0	65.0
2627	3.2	0.0	3.5	10.0	16.7	83.3
2629	6.10	1.2	2.8	4.6	14.7	85.3
273	3.4	1.6	4.8	8.6	18.4	81.6
277	4.7	2.4	4.5	7.3	18.8	81.2
278	5.2	0.6	1.6	6.6	14.0	86.0
2722	5.6	1.9	2.8	5.9	16.2	83.8
2723	2.9	8.2	4.3	8.0	23.4	76.6
2728	6.0	2.7	7.2	10.3	26.2	73.8
2734	4.8	5.7	7.2	11.1	28.8	71.2
2742	4.6	2.8	5.6	9.8	22.8	77.2
2767	5.0	2.1	1.5	2.7	11.3	88.7
2769	3.1	1.6	4.2	12.6	21.5	78.5
2770	6.1	.6	3.4	10.6	20.7	79.3

In a further general comparison of the Saskatchewan ball clays with those from England and the United States, the following observations are of interest, noted from the data obtained by Parmelee & McVay (21) and from other reliable sources.

In respect to the raw strength of each clay when mixed in a ratio of 1:1 with potters flint and calculated as the moduli of rupture the results are as follows:

TABLE XVII

Raw Strength Comparison

Total Number of Clays	Where From	General Average of All	Single Highest	Single Lowest
7	Kentucky	343.5 lbs.	427 lbs.	223 lbs.
5	Tenessee	378.6 "	478 "	293 "
15	English	426.5 "	568 "	345 "
21	Saskatchewan	701.5 "	1008 "	440 "

While there is little difference between the Kentucky and Tennessee clays, they are in both cases somewhat lower in strength than the English and are very much below the Saskatchewan clays. It is quite evident that the local clays are outstanding in the matter of their raw strengths, a property which is of major importance in the production of those wares where bonding clays are employed such as pottery bodies of thin cross section where their raw strength must be high to avoid excessive handling loss prior to burning. Another important use for clays of high bonding powers is in the manufacture of graphite crucibles and glass pots, though in these cases the clay, in addition to its bonding power, must have certain other highly essential properties. Hence it cannot be assumed that all of those clays which develop a high strength in the raw state are necessarily suitable for graphite crucibles or glass pots; only those which become dense fairly early in the firing range, with little further change in their porosity prior to overfiring at about 1,400°C. or higher. There are among the Saskatchewan ball clays some which offer much promise as bond clays; it is the author's opinion that the future will find the local clays of that type in demand.

Returning briefly to a further comparison of the Saskatchewan ball clays with those of the United States and England it should be noted that those from England are for the most part of the early vitrifying type, having little further change in volume below cone 12; it is for these reasons that the English clays are desirable and so widely used both in England and other countries. On the other hand the average United States ball clays vitrify more slowly, with a gradual reduction in porosity and a continuous volume change up to cone 12, conditions which are the opposite of those of the English clays. In Saskatchewan there are clays of both types, though in general their burned properties are more nearly like those of the English clays than are those of the United States.

In the case of the local ball clays, since there are different types which occur in each of the areas, it is to be pointed out that there are most favourable possibilities, by means of blending, to develop, standardize and control a wide range of the physical properties such that the most exacting market requirements for ball and bond clays could be met. To accomplish this a major research project would have to be carried out, followed by the construction and equipping of a modern washing and blending plant.

As in the case of the Willowbunch and stoneware clays of the province some of the ball clays have been found to contain scum-forming salts, which for slip casting are undesirable; in such cases a previous washing would tend to remove a portion if not all of the soluble salts, though it is most likely that when a pit has been well opened up and the clays worked back greater distances from the original exposed outcrops, the scum-forming salts may be expected to become less and less. The reason for this assnumption is the fact that the climate in southern Saskatchewan where the clays occur is at best semi-arid, hence for untold years there has been a fairly steady evaporation of ground or undercover moisture at the outcrop of the deposits; hence in case the evaporating water contained soluble salts through a leaching of them from the clay, then an excess accumulation would be left in the clay beds nearest to and at the extreme outcrop. In field sampling it is common practice to take the samples at exposed outcrops, therefore in such cases even though trenching has been done to obtain the sample a few feet back from the face, there would still be the likelihood of the presence of a higher content of salts than would be the case when the pit was well opened up for industrial usage.

In the past in a particular pit there was complaint of excess alkali in the clay the reason for this condition was not difficult to explain, since the original outcrop was along the old shore line of an alkaline lake, which no doubt contributed the troublesome salts. To avoid the removal of what was considered to be an excess of overburden the practice of working the pit or deposit was that of skirting along the valley side (the old shore line) rather than working at right angles back into the bench land where in all likelihood the occurrence of alkaline salts

would have been reduced at greater distance from the original front. While some of the clay from this deposit may not have been as free of alkali as could have been desired, it has been in continuous use for pottery over a long period of years.

While in the past it has been common practice to consider and to designate these clays as ball clays, there are numerous cases where, for certain reasons, some of them cannot be used for those purposes common to ball clays. While they are all of the same general class in so far as being highly plastic and for the most burning to white or at least light shades, there are wide differences to be noted regarding the presence or absence of speck-forming impurities, the percentage of water required to develop plasticity, their drying and burning shrinkages, their rates of vitrification, absorption and other changes with increase of temperature. Most of these variations are common to clays of the same type in other countries. It would therefore not be right to consider the local clays as being unusual, but extreme care should be exercised in the selection and development of such clays where they may be required for definite uses. Within the same deposit there are to be found variations in the beds or strata of clays which make up the deposit, and in addition, there is the likelihood of horizontal changes within the individual beds, hence the advisability of careful field and laboratory testing is to be strongly recommended in each case.

In the tables outlining the raw and burned properties of some of the clays under question, it is to be mentioned that those clays selected for the purpose were not taken as the best nor the worst but rather to represent the general average and to indicate any possible differences from area to area.

Of the thirty-six samples listed only two required less than 30 per cent. water to develop their plasticity; these, 3115 and 3116, were collected in the most easterly area, along the Souris River east of Goodwater. Their drying shrinkage is below the average but their burned properties are more nearly average, though as stated eleswhere in the report, the beds from which these samples were collected may not be in the true Whitemuds of the more westerly areas, and it is not certain that they are in place. On the extreme high side regarding the water of plasticity there were four clays which ranged from 40.2 per cent. to 47.4 per cent.; two were from the Verwood area, one from the Big Muddy Valley, and the fourth from near Niedpath, hence such clays are not common to a single district or area. Their drying shrinkages are high, especially that of clay 3046 which shrank 18.9 per cent. The fire shrinkages are also high and all trials were very dense and badly checked at the higher cones, a condition common to many dense burning ball clays if cooled too rapidly. Of the remaining trials, 16.1 per cent. required 35 to 38 per cent. of water of plasticity, and the balance 55.5 per cent., required 30 to 35 per cent. water with drying shrinkages in the general range of 8 to 10 per cent., which is normal for many ball clays.

It is not possible by means of the water of plasticity and drying shrinkages to note any particular differences in the clays from the several fields. On the other hand from the burned trials of the clays listed in the tables, and many other samples, it is quite apparent that there is more iron contamination in most of the clays farthest west, in the Fir Mountain area. While some of the clays in all of the areas develop specks when burned high enough, there are others which are speck free and many with only minor amounts such that they need not be ruled out for whiteware. In some cases the speck free clays occur between beds which contain few or many speck forming minerals, hence in such cases it will be necessary to use care to avoid contamination during the recovery of the better clay, or, in other cases modern refining methods may be employed to remove the impurities. In a few observed cases there are iron concretions of variable shape and size which occur quite irregularly in groups or localized pockets such that they could be avoided very largely by means of manual recovery methods which are most commonly used to win ball clays. In general, where the iron is in the form of these large concretions, the surrounding clay is free, or nearly so, of the small speck forming grains.

At this time it may be well to call attention to a condition which might prove quite misleading in the case of proving up an area of clay land by means of a core drill or boring machine. In the carrying out of such work the area is usually drilled by a grid of holes put down at 100 to 200 foot intervals in two directions. In the first case there would be an area of 10,000 square feet, and in the second case 40,000 square feet of clay area untouched by a drill hole; in either case pockets of concretions could easily escape detection and the clay assumed to be wholly iron free. On the other hand, if the iron or other impurities are very small and uniformly distributed throughout the clay, then the above testing of a property would reveal the true conditions.

Of the samples covered by the tables, 14.1 per cent. of them were speck free, 30.5 per cent. contained very few, 38.8 per cent. more and 16.6 per cent. many. In those cases where the clays are to be used wholly for whitewares then those highest in speck forming impurities could not be considered; fortunately, however, there are various other wares open to them where freedom from specks in the final ware is of little or no consequence. For instance there are those which are covered with coloured or opaque glazes and enamels; in sewer pipe, fire-proofing and face brick, when blended with other clays or materials to reduce their high shrinkage

and refractoriness; as bond clays in some refractories; as plasticizers in plastic refractory mixes and mortars and other wares; some may even offer promise in the raw state as drilling muds.

Naturally those clays which are speck free or very nearly so are to be preferred for all white or light coloured wares. It is becoming more and more common practice to wash or otherwise refine ball clays, so that clays which formerly were passed over are now made useable; it is also to be kept in mind that such clays are not used alone for whitewares, but are added to give plasticity and working properties to the non-plastic materials of the body mix such as the flint, feldspar, Cornish stone or other fluxes, and the kaolin. The quantity of ball clay required in a ceramic body generally does not exceed 35 per cent. and in some wares it may be less than 10 per cent. of the total body mix, therefore with such a dilution of the ball clay, plus the modern purifying methods and equipment now employed on the body slip, there is small likelihood of even a moderate amount of the speck forming minerals showing up in the ware. It is not at all uncommon to employ two or more different ball clays to supply the required amount of that type of clay; one may be used to develop certain properties to the slip or raw body, while a second and even a third clay may be required to develop the necessary burned properties. In such cases the likelihood of specks would be materially reduced through the greater dilution attained.

The 1931 exposure of Whitemud beds at C.N. Ry. trestle over Jewel Creek east of Goodwater, Sask. Beds were trenched in 1946-47.

Whitemuds shown in lower right hand corner, at base of Ravenscrag beds, north wall of Big Muddy Valley. Near the west end of Big Muddy Lake.

While some of the Saskatchewan ball clays check during rapid cooling, this condition is of little concern in that even the most dense-burning clays when blended with the other necessary whiteware materials, or grog in the case of refractories, no longer act in the same manner, nor is the rapid cooling of small test pieces duplicated in most industrial practice.

Most ball clays develop white or light shades up to and including moderate whiteware temperatures; there are some which change to grey or bluestone shades at the higher temperatures represented by cones 10, 12 and 14, but even so they are widely used for certain wares. In general, the raw and physical properties of such clays are considered to be of more importance than the slight alteration of body shade which they may impart.

Comparison with Standard Ball Clays

Through a brief review of the burned shades of certain well known ball clays from England, the United States, and those from Saskatchewan the following comparison has been made.

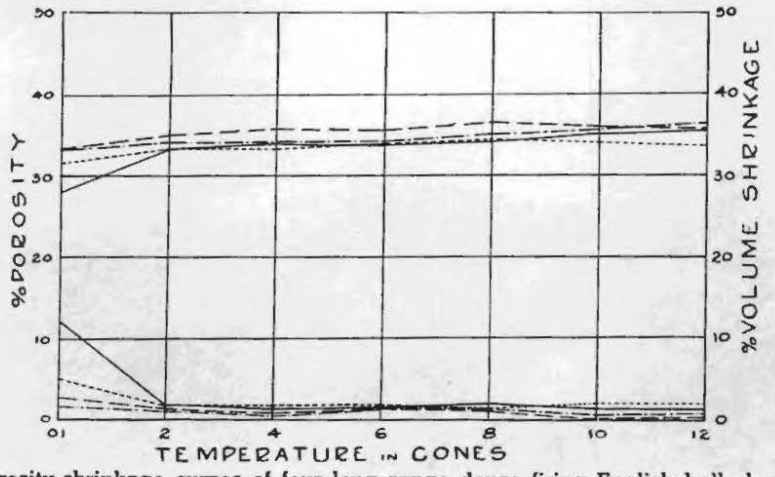
TABLE XVIII

Burned Colour Comparison

Ball Clays From	Per Cent. Bluestoned at Cones				Remarks
	8	10	12	14	
England (21)	7	64	64	85	21% improved by washing
United States (21)	16	50	66	90	16% improved by washing
Saskatchewan	17	17	32	51	All unwashed samples

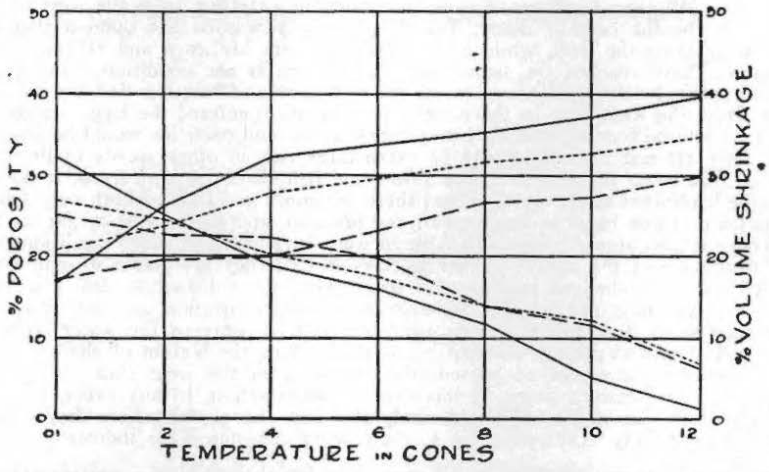
To obtain the figures for the Saskatchewan clays, forty average Saskatchewan ball clay samples were taken at random as the source of the required information, and it is felt that the percentage figures are very close to a general average for the Saskatchewan clays. Granting this to be the case, then the local clays rank higher in the percentage of non-bluestoning clays than is indicated by the English and United States ball clays, at least those investigated by Parmelee and McVay (21).

In further reference to the Saskatchewan plastic Whitemud clays, it is to be noted that they are open to choice in the matter of the time, the rate, and, the amount of their vitrification There are those which start to vitrify very early and then continue at a slow gradual rate to the higher temperatures, in some cases not reaching zero absorption. Others vitrify and become very dense quite early, then remain fairly uniform until a degree of overfiring has been reached; this type resembles some of the more desirable English ball clays widely used in pottery. There is another type of Saskatchewan clay which remains quite open and not overly dense at cone 14; clay 3904 is an example of this. While the above are the major types, indicated by curves in Fig. II, there are numerous intermediate variations such that where it is desired to favour certain wares or to meet fixed temperature conditions, then a suitable selection can, or should be made, provided that the other properties of the clay may be satisfactory. In most cases it will be found better to blend two or more clays rather than to depend on a single clay which might vary somewhat in its composition and properties from time to time, conditions which would be unlikely to occur in the case of a carefully blended mixture of clays.

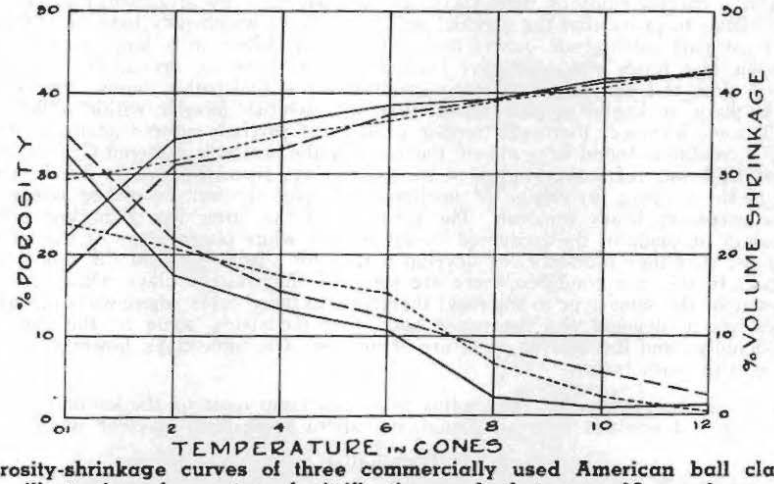


Porosity-shrinkage curves of four long range dense firing English ball clays. This type is desired for many uses.

Among the Saskatchewan ball clays are a number which are outstanding in that they not only burn white but they remain white at cone 14 with no signs of bluestoning. They are therefore of interest where freedom from colour is desired in certain wares like high fire porcelain. Clay 2770 (92) is an example of this type.



Porosity-shrinkage curves of three commercially used American ball clays, illustrating a medium rate of vitrification. Cones 10 to 12 and higher necessary for max. density.



Porosity-shrinkage curves of three commercially used American ball clays, illustrating slow rates of vitrification such that cone 12 or above is necessary to develop max. density.

Kaolinized Sandy Clays

GEOLOGICAL COMMENT

Quoting from McLearn (1930, p. 54B) "For over three years, since the beginning of this study, fossil evidence for the age of the Whitemud formation has been sought without results. On the basis of general stratigraphic relations, the writer has suggested an early Lance, Edmonton, or some intervening date. More recently Russell, in an interesting and informing paper on "Upper Cretaceous Dinosaur Faunas of North America" suggests a correlation with some upper member of the Fox Hills series in central and eastern Montana."

In the past there has both in and out of print been some divergence of opinion regarding the original source of the material composed by the Whitemuds, Davis (3) being of the opinion that it came from Pre-Cambrian to the east; in substantiation of his views he referred to the higher degree of refractoriness of the more eastern Whitemuds in Saskatchewan. While

this is true as to their purity and higher resistance to heat than those in the west, it cannot be accepted as definite or unquestionable proof of the source of origin, in that some clays may have been purified through longer distances of transportation by water, thereby permitting the removal or settling out of impurities at or near the source.

That the Whitemud sediments came, not from the east, but from the west or southwest, is now held to be the case by many. Terrell very early was of the opinion that the plains sediments were from the west, while in more recent years McLearn and others, including the present author, have reached the same conclusion. There is one condition, however, which is difficult to explain by those who hold to the western source. Admitting that the inflow of sediments was from the west, then as the waters carrying them entered the large sea or lake areas the velocity would be reduced and the heavy coarse sands and particles would be discarded first, while the finer grained material would be carried far out, in other words to the east; while this may be true in so far as the plastic Whitemud ball clays are concerned, it does not hold true with the kaolinized sandy clays, in that there are zones and beds of both very fine and very coarse grades of those clays in the west of the province and to the east as far as the Souris Valley. There is also ample evidence that there were very unusual water conditions during the early sedimentation of the sandy Whitemud clays in that they are found in many cases to be crossbedded and to be changed in grain size within very short distances, clearly indicating that there was a re-washing and possibly some secondary transportation and deposition, such that coarse grained sands deposited originally near the western shore of the water body may have later been picked up and carried eastward many miles along the bottom of shallow water areas. There is a similar movement of present day sands from the west shore of Candle Lake, Saskatchewan, to its eastern shore, in this case by wave action. In any event, there are variations in the grain size of the kaolinized sandy clay beds, no matter where they occur, so that they should be carefully examined prior to their being considered for industrial developments.

Not only are there variations in the grain size, but there is also a considerable difference in the percentage of recoverable kaolin within beds in the same deposit, and where this occurs a difference in the pyrometric values is noted; the kaolin yield in some cases is as low as 10 per cent. and in other instances above 50 per cent. Ranges as wide as those would in a large measure explain the difference in resistance to heat.

From a careful study of these clays, as has been made by McLearn, there is fairly conclusive evidence to prove that the original sediments, from which they have been formed, were for the most part sand grade quartz and feldspar, the latter in a large measure unaltered, though some in a lesser way may have been in a semi-altered or decomposed state. With the passing of time and suitable weathering conditions the feldspathic sands were very largely altered, in place, to kaolin as now found, that of a whitish powder within a field of quartz grains; in some instances there still remain coated and partially altered grains of the original feldspar, a condition found in some of the beds in the westerly Eastend-Cypress Hills area. The generally lower refractory values of the sandy clays from the west is due in a very large measure to the varying percentage of unaltered feldspar, through unleached released alkalies, and some accessory heavy minerals. The presence of the latter has a marked effect on the burned colour or shade of the recovered kaolin and the white plastic clays of the western area; for the most part they bluestone, or develop darker off shades than do the sandy white clays to the east. In the raw condition there are some of the western clays which are equally as white as any of the same type to the east; therefore, in those cases where white or light coloured raw clays are in demand for the paper and other industries, some of the deposits in the Eastend, Knollys, and Ravenscrag areas are of interest. The same clays, however, are unsuitable for use in whiteware bodies.

It is for this reason that the kaolins recovered from most of the kaolinized sandy clays to the east are of greatest interest, though not all of these burn to clear whites.

Distribution

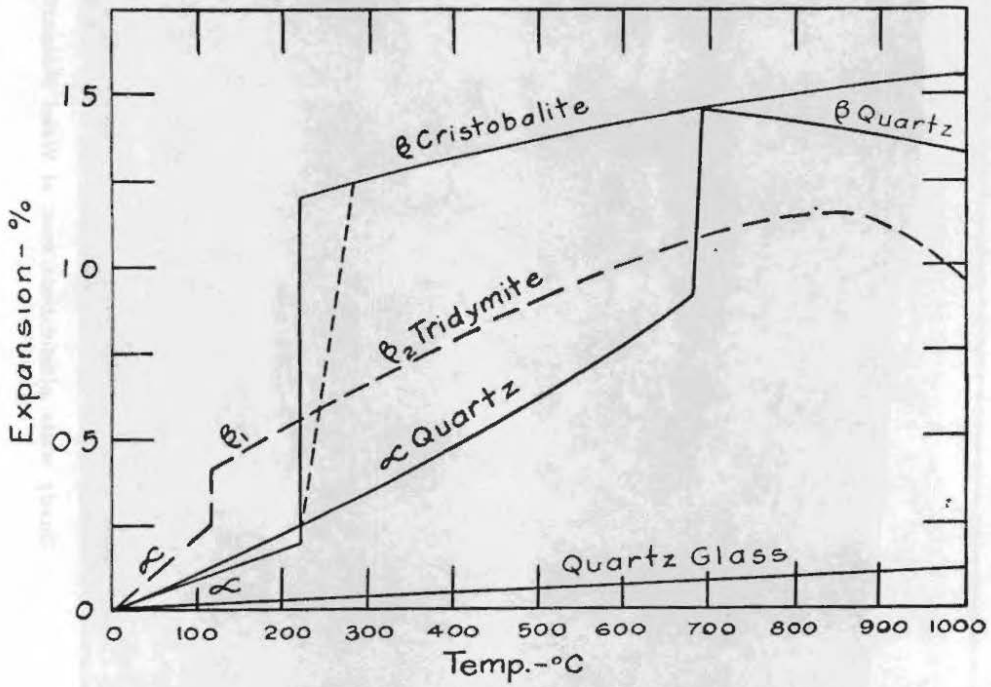
The clays of this type are light coloured and at a distance the outcrops appear snow white or chalky, thus making it an easy matter to observe and trace the formation in which they occur. Good exposures may be seen in the Cypress Hills area in the west, south eastward on the Frenchman River in township 5, range 20, west of the 3rd meridian, to the east and south of Fir Mountain, near Wood Mountain, Flintoft, along Twelve Mile Lake, at Willows and Readlyn, at the upper or west end of Willowbunch Lake, Big Muddy Valley, in the Dirt and Cactus Hills near Claybank, and at a number of outer points south of Beechy, north of Aquadell and Braddock, Avonlea Creek, Souris River Valley and others. In other words, these clays are widely distributed from west to east across southern Saskatchwan, but except for a few isolated small exposures, they have not been found in general north of the Dirt and Cactus Hills. It is not unlikely, however, that they were ever deposited very far north of the deposit south of Beechy; roughly it may be stated that the chief areas of those clays are south of the main line of the Canadian Pacific Railway.

Uses

The kaolinized sandy clays are of interest both from the viewpoint of recovery and refining of their kaolin portion and for use in their natural unrefined condition. Among the

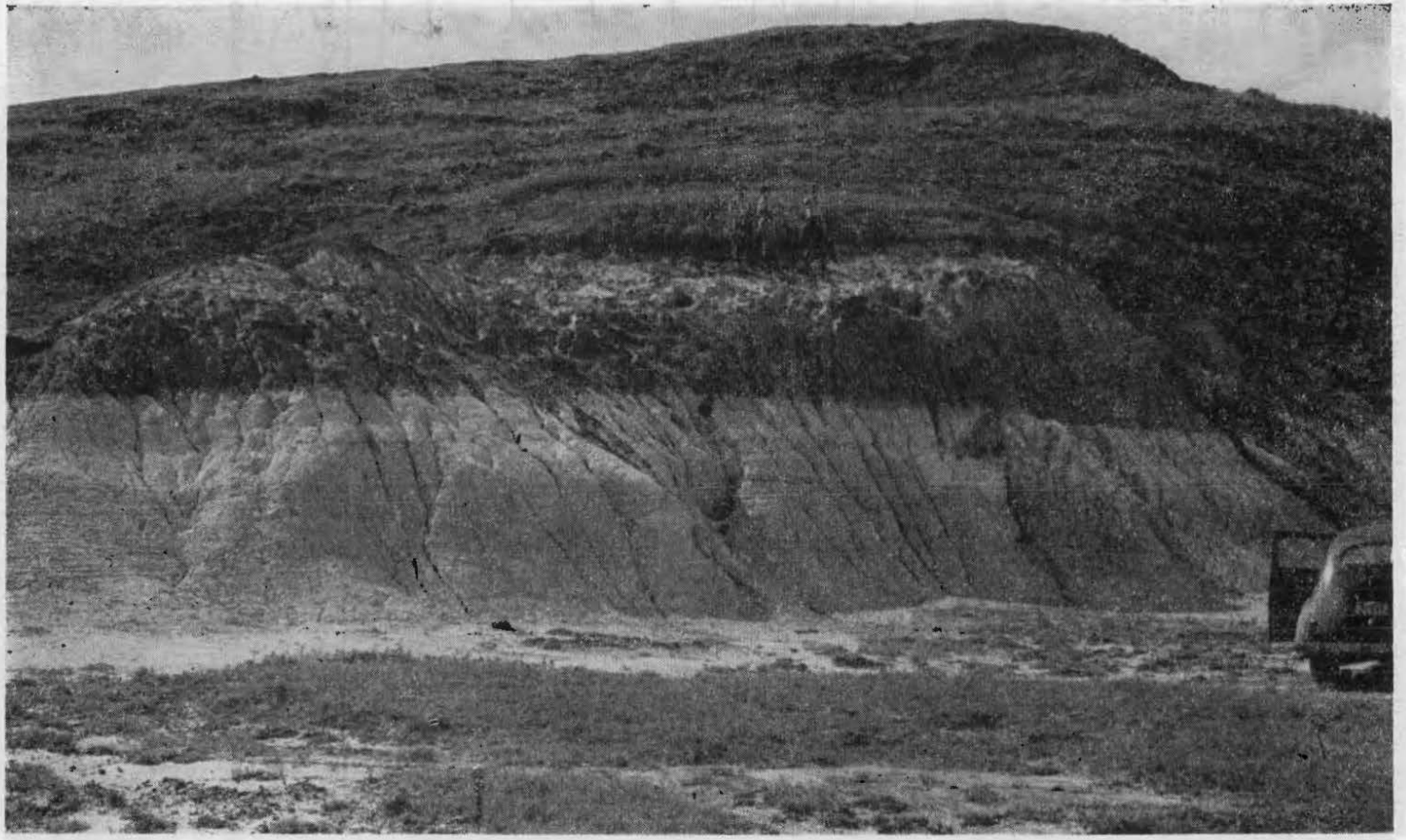
more general uses for these clays in their natural state are: as a non-plasticising (grog) addition to certain other clays where a reduction of plasticity and shrinkage may be desirable. For this purpose and in other cases to increase the degree of refractoriness somewhat, they may be used with other clays for wares like sewer pipe, terra cotta, fire proofing, and other structural wares like face brick and building tiles.

Certain of the finer grained and more pure sandy clays are useful with yellow ware stoneware Whitemud clays for the production of those classes of wares, but they cannot be used alone in their raw unrefined condition for any type of pottery. By test some of the beds of the kaolinized sandy clays can be classed as either semi-refractory or refractory; the great majority of them are of P.C.E. values below cone 30, and therefore fall into the Intermediate or Low heat duty classification of the A.S.T.M. There are a less number with P.C.E.'s of cones 30 to 31. Those of the latter values are of the High heat duty class. While certain of these clays qualify as refractories in so far as their P.C.E. values are concerned, it may be well to recall the discussion of other prerequisites of various types of refractories mentioned under the heading "Fireclays" in Chapter 2. Notwithstanding the fact that the kaolinized sandy clays in their natural condition possess in many cases ample P.C.E. values for certain refractory use, they are not entirely satisfactory for that purpose in that products made from them have a low resistance to sudden or rapid temperature changes. Under such conditions the ware, due to internal strains which are set up, tends to crack and eventually becomes weakened. The major cause of these strains is that of the sudden and abnormal expansion and contraction of the silica sand and its modifications in the body when heated and cooled. The following curve sheet shows the degree and temperatures at which the three forms of silica alter in size by a rise or fall of the temperature at the critical periods.



Curves illustrating the per cent. expansion of different forms of quartz. Tridymite being the most desirable in siliceous refractories.

It is to be noted that any of the silica, which during the burn, or while in service, has been converted to cristobalite will expand sharply in the general range of 220°C. and the quartz, though somewhat less, at 575°C. The third form, tridymite, has a small inflection only at an early temperature. In that these major changes in size of the three forms of silica are reversible, then each time a refractory containing them, especially cristobalite and quartz, is heated up above 600° C. and later cooled down to below 220° C., it will have passed through four severe strain periods, two on the way up and the same while cooling down. Therefore, in the case of wares made from the refractory siliceous (sandy) clays, it is not surprising that they are prone to cracking defects, since through tests they are known to contain on the average about 40 per cent. free silica and in some cases over 60 per cent.



Sandy white plastic beds west of Wood Mountain (4617)

A possible way to extend the use of these clays for certain refractories would be to to refine them in such a manner that most of the silica would be removed and the clay portion recovered; the latter would be largely kaolin which could form the basis for the development of a range of refractory bodies. However, from a commercial point of view there seems little to recommend such an undertaking, except for a restricted line of refractories. The cost per ton for the kaolin would be quite out of line to permit of its use in the bulk standard types of refractories where very large tonnages of clays are required. The chief use for the sandy clays, as earlier stated, will not be that of their use alone for refractories but in a lesser degree with the plastic fire clays for some types of wares, especially those not entering service where the heating and cooling conditions would be of a detrimental nature.

While the kaolinized sandy clays may be restricted in their future use for refractories, there are possibilities along other lines for the kaolin contained in them, provided it can be recovered economically, of suitable purity, colour and physical properties. Among the more important and larger markets for the washed kaolin will be those of the paper and whiteware industries. In the former case there are two types of clays employed, the one as a filler and the other for coating. For these uses the clays must be of very fine grain, free of grit and mica, of high retention properties, and extreme whiteness in the case of coating clays; the requirements with regard to whiteness are less exacting for the filler clays, such that in some cases slightly off shade white is acceptable. At the present time some of the Saskatchewan clays which have been under washing and refining tests during the past year offer much promise with respect to their meeting the required specifications of the paper industry. On the other hand, the marketing conditions are not as favourable as could be desired, in that they fall under the following adverse conditions:

1—There are no paper mills in the mid-west near the clays.

2—To reach the large paper producing centres, the western clays are handicapped by the long haul and high freight charges to those markets.

3—The mills in the East are supplied by clays shipped by water from England, and over a shorter rail haul from the United States, so that there is little likelihood of the western clays competing on an equal basis in the East under the present conditions. The mid-west markets at the lake head, while not so large as those farther East, offer possibilities in the meeting of competition on a more favourable basis.

Another major use for kaolin is in the production of sanitary ware and whitewares. For those purposes it is blended with other raw materials such as ball clays, potter's flint, feldspar, and in some cases Cornish stone, nepheline syenite, talc or other materials; some of the body mixes may contain very little kaolin while in others as much as 50 per cent. may be used. Again the question arises relative to markets for Saskatchewan prepared kaolin in the above wares; as with the paper clays, at present the largest market would be in the East, particularly Ontario and Quebec. In view of the unfavourable competition in those areas for the western clays, the outlook for shipments to plants in those parts is not encouraging, and in case of further increases of freight rates the possibilities will become practically nil.

There is at present a fair consumption of imported kaolin in the west, that used by the potteries in Alberta, a market within easy shipping distances for any future kaolin produced in Saskatchewan, and one which may be considered favourable in the event that the local clay can be produced at a price and of equal quality to that now in use. The production cost of kaolin hinges very largely on two factors, first: the yield from a ton of raw material, and secondly: the tonnage of daily output. The first of these, yield, can be considered satisfactory; the second is therefore the one which controls the feasibility of establishing a kaolin washing plant in Saskatchewan, or elsewhere in the west. It is not a matter of building a plant capable of producing a very large tonnage per day, but of finding a market to absorb the output of a plant of sufficient capacity to justify the necessary investment, so that the final product can be produced at a price comparable with that of kaolin recovered at plants in the United States. The present consumption of kaolin by the potteries in Alberta is not sufficiently great to warrant the construction and operation of a kaolin washing plant for that market alone; other outlets would be necessary as well.

In the event of paper mills, various whiteware plants and other kaolin consuming industries being established in the mid-west areas, then Saskatchewan will be in a favourable position to supply their requirements.

5. Future Possibilities and General Remarks

In the conclusion of this report it seems desirable to present, rather informally, some of the observations and thoughts of the author which have resulted from his past work in connection with the clays of Saskatchewan. They are given in the hopes that they may prove helpful to all those who are or may be concerned with the local clays and their development; others will find the material of little more than passing interest.

That there are many useful clays in the province needs no further comment. They range in type from the low grade surface clays to the high grade white burning refractories useful in pottery. Their individual importance, however, is not that measured by grade alone, an unwarranted common assumption which no doubt arises from the fact that the deposits and quantities, the world over, of the higher grade clays are far less than are those of the lower grades. This is quite true in Saskatchewan where many have the opinion that the former type are of greater importance to the province than the latter. This is a debatable question and must be considered from several angles, dollars and cents in one case, or general service to the people in another.

To be brief, while the higher grade clays are useful for pottery, where necessary to the welfare of the people, it is a commodity which has and can be shipped in from the older pottery producing countries. While this is not to be desired, the fact remains that pottery requirements are not wholly dependent on the local clays. On the other hand the lower grade red or buff burning clays and shales are necessary in a much larger way, that of their use in the construction of even the most lowly home to the large public buildings of architectural beauty. While in the past millions of brick and tile have been manufactured in the province from these clays, the future will find them to be in ever greater increasing demand and service to the people. Though the tent, the "soddie", the shack, and the frame structures have all had their day, the present and future demands are, and will be, for the more durable types of building materials, particularly well burned clay bricks and hollow structural tiles.

Inasmuch as the structural clay wares are of the heavy type, there is no possible chance of their being shipped into Saskatchewan from more distant points, provided they are produced locally in sufficient quantities and kinds to meet the requirements and demands. Quite naturally the quality of the ware and its price to the user must be such as to avoid nearby competition.

In view of the expected future growth of the west, there seems to be little doubt regarding the importance of and the part which the lower grade clays will take in that great forward movement. The many homes and buildings of all classes will require the output of far more and larger plants than exist today. Both face and common brick or their equivalents in other units will call for a maximum of production. Therefore, the importance of those raw materials, the clays and shales, which will be required is not to be underestimated; it is not too early to start giving thought, attention, and research to them on a par with that devoted to the higher grade clays. There is much to be done with the structural raw materials, such as improved manufacturing and burning methods, to develop suitable ranges of shades, colours, and surface textures. The development of a burned clay insulation product, and many other investigations are worthy of careful study. In the matter of money value the structural wares of the industry hold a very high position.

Care will be necessary in selecting the better raw materials, the location of the plants in relation to the clays, to fuel, water and living conditions. The best of these seldom all occur together, desirable though that would be. The recent surface clays should receive very careful attention regarding their extent, uniformity, and freedom from objectionable lime pebbles, alkalies, etc. They are to be looked for in that area of the province which has been glaciated, and along the flats and terraces or benches of streams as recent alluvial clays.

The shales occur in most of the geological formations of the province, though some contain shales of questionable value in the light of present knowledge, those in the Bear Paw for instance. There are, as stated in the body of the report, sufficiently ample supplies of suitable shales that there need be no worry for the future. In those countries where shale is abundant it is more generally used for the better class of structural wares than are the more recent soft clays. Especially is this the case where higher degrees of vitrification are required as in face brick for severe climatic conditions, in floor and quarry tile, paving bricks, sewer pipe and other wares. For the more common wares the clays are of particular interest in that they are less costly to prepare for manufacturing and in most cases require lower burning temperatures.

Among the important clays of greater age than the surface recent ones are those of the Willowbunch beds and the plastic beds of the Whitemuds in the Cypress Hills area. They occur in large quantities in both cases and they can form the basis for many large ceramic product industries. In general they offer far greater possibilities for the development of more kinds of wares than do the higher grade white burning clays of the province, and when fully utilized, their total value return to the province will far exceed that of the higher grade clays. This will be so in that the kinds and varieties of wares which can be made from them exceeds that of the other clays by many times; there is also this factor to be given consideration, that

the Willowbunch and the Cypress Hills clays do not require for their wares the additions of other materials like potter's flint, feldspar, Cornish stone, nepheline syenite, etc., as do the white burning pottery clays. While the two lower grade types of clay can be used one hundred per cent., it will be found necessary in most cases to blend different beds to develop certain temperatures for burning or to increase or decrease vitrification. Fortunately such blending is easily possible.

The following is a partial list of the useful ceramic products which can be made from them: face brick, glazed brick, common brick, all types of other structural wares, sewer pipe, fire proofing, flue lining, chemical stoneware, yellow ware, stoneware, artware, quarry tile, floor tile and other wares. It is not likely that any other types of clay or shale in the province will prove as valuable or be as extensively used in the future as will those of the Willowbunch and the buff burning Whitemuds.

In the case of these clays as in that of the Whitemuds in general, the deposit should be carefully investigated, particularly for two conditions, changes in thickness of the beds and that of lateral physical variations. While there are many that are uniform, it is not uncommon to observe rather sudden changes in thickness and physical properties within quite short distances. Therefore in the case of development these vagaries should be known well in advance, so that provision can be made to avoid possible difficulties. There is also the matter of overburden to be given consideration; in general it is rather excessive but with the larger and more modern stripping equipment, deposits which were formerly too expensive to work are so no longer, and it is most likely the future will prove the same.

All that was said in reference to research and investigations on the red burning shales and clays can be applied in the present case, though there is much more to be added due to the greater variety of wares which are possible from the clays just discussed. In fact it will take years to fully develop all of the uses and possibilities for these clays.

The more widely known clays of the province are the ball clays of the Whitemud formation; their distribution is now well known and their chief raw and burned physical properties have been investigated sufficiently to demonstrate their importance to the future of the province. The past studies and investigations on them have fully proven the need for more extended field and laboratory work. In the field, further attention should be given to intensive studies of the more favourable deposits and areas, the work to consist of core hole sampling and laboratory testing on a scale sufficient to prove up workable areas of uniform quality clays. This important work is now, for the first time, under way by the Department of Natural Resources. It is only by such means that large users of these clays can be interested. They must first be assured of quality, but of equal importance to them is quantity, that sufficient to supply their requirements for years. To change clays or to have the quality of a clay change is a serious and often a costly matter for a large firm producing wares in which ball clay and kaolin are used.

That these clays are high grade and of material value to the future of the province needs no argument by those qualified to judge. In their development the actual money value return to the provinces will be from two sources, that of their use locally in the production of wares in which such clays are employed, and that of their export to other markets in Canada and elsewhere; it is not unlikely some may take exceptions to the latter disposal of the clays, saying that it would result in the loss of employment for Saskatchewan labour and that goods manufactured elsewhere from the local clays would be returned as competition to the home industries. In opposition to such reasoning one might cite the case of England, one of the world's largest producers of pottery wares, wares in which their local clays are used; she also exports those same clays to practically every country in the world, and in doing so it cannot be said that there has been any resulting curtailment of home production, while on the other hand there has been a greater use of labour, that required to win, refine and load the vast quantities of clay which are exported, employment which otherwise would not be available; the same may be said of the future of the Saskatchewan clay industry.

In addition to the clay sent out of the province for use in the manufacture of wares, there are favourable possibilities for an out-of-the-province market of raw clays useful in the manufacture of paper. In respect to them much remains to be done regarding an economical and satisfactory method of separating the kaolin from the gangue materials. Up to the present the elutriation and flotation method has been under investigation with a fair degree of success.

The refractory clays of the province are found in the Whitemuds though some of lower refractoriness occur in the Willowbunch beds. Up to the present none of the more highly refractory materials, such as diaspore and bauxite, have been discovered in Saskatchewan, hence these as required for special uses must be brought in, the nearest known source being the state of Missouri. The general range of refractoriness of the local fire clays extends from those suitable for low heat duty fire brick, cone 19, to those required for high heat duty, not lower than cone 31-32. In special instances through careful selection of the clay it has been possible to produce a P.C.E. of cone 33.

While a very wide range of refractory products are now made from Saskatchewan clays such that they serve in a large way many of the industries and the railways of western Canada,

there are some services where the high aluminous super duty refractories are necessary. While much research work has been done in the past regarding the development of suitable fire clay mixes for the many services, there remains much more to be done, especially in the development of a super duty clay fire brick. To that end prospecting in the northern areas for diaspore or other like materials would be a worthwhile undertaking, and, as mentioned earlier in the report, the kaolin recovered from some of the sandy white clays may prove of interest to increase the refractory quality of certain high P.C.E. value clays now in use. There is little doubt regarding the future importance and value of the fire clays and the refractory industry to the province.

It may be well to mention that the refractory industry is a major branch of ceramics and is one not suited to small plants but rather to that of very large ones where the investments and ouput are such that the necessary technical staff, laboratories, scientific and control equipment and general supervision can be provided and continuously maintained. It is only necessary to refer to the advancements that are being made in the fields of refractories in practically all countries, particularly in England and the United States, to realize that in no other branch of ceramics is research and control a more important prerequisite to successful development.

In addition to the clay samples covered by this report there is a far greater number which have been reported on from year to year in the form of Annual Reports now on file at the Department of Natural Resources, Regina, to whom inquiries should be directed. In each report data regarding the location, details of thickness, working properties, behaviour during burning, colour and other information of each sample are given, such that clays of different types and possible uses may be located for further investigations.

In conclusion it may be said that the clays of Saskatchewan are one of its more important natural resources; they have served well in the past development of the province and there are good reasons to expect them to be of far greater service and value in the future, wholly in keeping with the inevitable growth of the province and the Dominion as a whole. Through the clays much new money will be brought to the province from outside markets, both for the raw clays and for the wares made from them. To this end, time, research, interest and effort will all be necessary.

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To the many assistants who were engaged from year to year in conducting the desired laboratory work on the hundreds of samples, the author desires to express his appreciation and thanks for the interest which they took in their part of the work and for the high quality of same.

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The maps regarding the geology of the province and the general location of the clays used in this report were prepared in the Department of Natural Resources under the supervision of Mr. A. J. Williams of that Department. He has also provided the statistics, certain notes and charts concerning the past production of clays and clay products in the province. The keen interest taken in the matter of making this report possible by Mr. C. A. L. Hogg, Deputy Minister of the Department of Natural Resources is gratefully acknowledged, and, lastly the helpful and pains-taking assistance in the preparation of the manuscript for this report by Roberta Quandt (nee Ferguson) and Miss Amy Barber is also gratefully acknowledged.

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The author wishes to express his very great appreciation for the help and use which he has made of the information contained in the publications of the authors listed, as well as many others. A conscientious effort has been made to give full credit to each. He further wishes to thank the McGraw-Hill Book Co., The A.S.T.M. and others for their kind permission to make certain abstracts of material contained in their publications.

APPENDIX A

Summary of Annual Reports

The following data and material, for the most part widely scattered in annual reports, has now been collected, condensed, and brought together as a part of the main report. This makes available a vast amount of detail which might otherwise have eventually become lost.

The material herewith presented will in a small way give some idea of the volume and magnitude of past work devoted to the clays of the province. The author has analysed the data on each sample and has in brief made comments regarding the uses, the good or weak properties, etc., of each, and in doing so has drawn, for his conclusions, upon the knowledge gained through many years of testing clays and determining their best uses.

Much of the information will be of value in the negative sense, in materially assisting in the avoidance of those clays of little or no further interest. On the other hand, it is hoped that those in search of a particular kind of clay or for information on all clays of a certain area or district, will find the following tabulations helpful.

It is to be regretted that it is not possible to supply any data regarding the samples collected during the years of 1921 to 1925 inclusive, the reason being that the samples and results of the laboratory work for those years were lost when the fire in February, 1925, completely destroyed the engineering building of the University in which the Ceramic Department was located. It was therefore necessary to repeat much of the field and laboratory work.

NOTES ON SAMPLES COLLECTED IN 1926

For the most part, the forty-one samples collected were repeats of the more important ones destroyed by the fire of the previous year. They were from the Willows-Readlyn, Verwood-Willowbunch areas, and, farther west in the general vicinity of Eastend. From the areas in the east samples of the ball clays and kaolinized sandy clays of the Whitemud were collected, while from near Willowbunch a few collections were made of the Willowbunch clays. In the west the samples were of the plastic stoneware type of the Whitemud. The laboratory work was restricted to preliminary tests only, though sufficient to classify the clays and to learn of their general purities and uses.

Nine of the ball clays first collected in 1926 were resampled a year later and were included in the work "An Investigation of Twenty-one Saskatchewan Ball Clays", published in the Jour. Am. Cer. Scy., Vol. 12, 1929, pp. 360-376.

Sample No.

261—4 feet.
262—8 feet. *Location*—W.½. 10-5-27w2. East of Willowbunch.

261—This clay is cream coloured, some iron stain, has black specks, earthy fracture, is 3+ feet thick, good plasticity, dried safely, burned shades at cone 06 to 9 inclusive buff to greyish-buff, may be considered for heavy pottery, face brick, sewer pipe, fire proofing, etc.

262—Dark, nearly black, carries white specks and dark streaks or tap root remains, conchoidal to earthy fracture, fine grained, good plasticity, shrinkage high, is 8 feet thick, burns to a clear buff cone 06 to 9 inclusive, uses same as 261.

No. Sample

263—4 feet.
264—2 feet.
265—3 feet. *Location*—N.W. 15-5-28w2. Northwest of Willowbunch.
266—4 feet.
267—4 feet.

263—This clay corresponds in all respects to clay 262 and needs no further comment other than it is 4 feet thick and is at the top of the deposit under heavy overburden.

264—This clay is dark grey to black and is just below No. 263; it carries dark specks and tap root remains, its fracture is earthy, it has a greasy feel when rubbed, is fine grained and highly plastic, has rather high shrinkage. At cone 06 it is a nice clear buff; at 02 a nice shade of canary yellow; it starts to bluestone at cone 3 and is overfired at cone 9. It would require washing for heavy pottery but not for face brick, structural tile or sewer pipe. Its shrinkage could be improved by an addition of clay 267 in the same deposit.

265—This clay is separated from clay 264 by a 1½ ft. seam of lignite. It is light grey in shade, has conchoidal to earthy fracture, little evidence of lamination, is semi-gritty, but is fairly fine grained, of good plasticity and working properties, dried safely. It was a clear buff at cone 06, clear creamy buff up to cone 3, then bluestones at cone 5 and above with no specks. This clay would have the same uses as 264 and could be blended with it. It is free of dark specks and might not require washing.

266—This clay is of a buff-greyish shade with some iron stain. It is more gritty than 265 just above it, its fracture is earthy, and some lamination is present. The working properties are good, drying is safe and at cone 06 it develops a very light cream shade, and then takes on a slightly darker shade, free of specks at cone 02 to 9 inclusive. It differs from 265 in that it does not bluestone. It could well be blended with all of the clays above it and would improve their properties, or it could be used alone other than its absorption is a little high for stoneware. On the whole it is the best seam of clay in the deposit.

267—This is the lowest seam of the deposit and is a light grey kaolinized sandy material, loosely consolidated, carries dark grains of sands other than the quartz, it is coarse textured and of earthy fracture, when wetted it has a strong clay odour. Its plasticity is weak, the shrinkage and dry strength are both low, though these would be improved by the inclusion of 1 foot seam of interbedded plastic shale which was left out of the sample. This sample is semi-refractory but is too coarse grained and short to be used alone. Its chief value would be as a leaning agent to some of the clays above it.

Overburden—30 feet.
Lignite—2 feet.
2611—10 feet.
2610—2 feet. *Location*—W.½. 12-6-28w2. West of road midway between
269—2 feet. Highway No. 13 and Willowbunch. Many carloads of ball clay
268—4 feet. from these beds have been shipped to the United States.

268—This is a dark chocolate to black clay, it is very fine grained and feels greasy when rubbed, it breaks out in blocky form. It carries plant imprints of carbon or coal-like material and has light specks and streaks. It is a ball clay which has fair plasticity and working properties, though ball clays are never used alone. When burned from cone 06 up to cone 7, it develops a buff shade which becomes a little darker at cone 9. Its general use would be in pottery though not for ware which must be white.

269—This is a grey to dark chocolate or black clay of a blocky nature. There are plant or tap root replacements, is non-greasy to the feel, and is rather dry and coarser grained than clay 268 just below it. It is less plastic and of lower shrinkage. When burned, it remains a light buff up to cone 9; some dark specks develop at the higher cones. The general uses are those of a ball clay or semi-refractory where iron specks would not be harmful.

2610—This clay is just above 269 and is of a lighter shade, its fracture is semi-conchoidal, some light streaks are present, it has a dry gritty feel and its working properties are very much the same as 269. At cone 06 to cone 3 inclusive it burns nearly white and free of specks. At cones 5, 7, and 9, it remains nearly white but carries some specks. It would be necessary to wash and use a magnet on this clay for use in whiteware as a ball clay.

2611—This sample is of a greyish shade, conchoidal fracture, dry and gritty, with many visible small iron grains and stems; its working properties were good, being a ball clay type its shrinkage was too high. It burns from a pink shade at cone 06 to a light cream at all cones up to cone 9. It is very dirty with numerous iron specks from cone 3 to cone 9. It would require to be washed for use as a ball clay.

2612—This sample is from the same bed or seam as clay 268 other than from another outcrop nearby. Its burned shade is a little darker than 268, conditions otherwise the same.

Overburden 30-40 feet.
Iron Stained Clay 3 feet.
2614—9 feet.
2613—10 feet.

Location—S. 6-7-27w2. About one quarter mile north of the Verwood cemetery on Highway No. 13.

Sample No.

2613—This clay is nearly white and while a little more gritty it is practically the same clay as No. 10 on S.½. 33-7-28w2. It carries some iron stain and very fine grained pellets or concretions. It has an earthy fracture and breaks out in blocky form, it is gritty, the plasticity is good and shrinkage satisfactory. When burned it is a light pink at cone 06, then changes to a light cream and greyish buff from cone 2 to cone 9 with specks starting to show at cone 3. Its general uses would not be as a ball clay other than for cream or non-white bodies, it would require washing. Unwashed it could be used in face brick, saggers, sewer pipe, terra cotta and other structural wares. Its chief disadvantage is the excessive overburden.

2614—This is a grey plastic clay which rests on the last sample. The fracture is conchoidal, has a gritty feel, is laminated in part, carries iron stain and small grain size impurities. These were largely removed by washing. Its plasticity is good but a little sticky. Too much drying shrinkage to be used alone, would require grog or additions of a more sandy clay. It burns pink at cone 06, and light cream from cone 02 up to cone 9, a few specks appear at 02. Its general uses would be much the same as 2613 just below it, though it can be greatly improved if washed. The overhurden is a serious handicap to its development for use. For greater detail regarding this clay see J.A.C.S. Vol. 12, 1929, p. 360.

Overburden—15 feet.
Lignite—1 foot.
2617—12 feet.
2615—10 feet.
2616—? feet.

Location—S.½. 33-7-28w2. On south side of valley about midway between Willows and Readlyn.

Sample No.

2616—This sample is a greyish sandy clay at the base of the deposit; only a few feet were exposed for sampling. The quartz grains rather large for sands, some small dark grains also present, some stratification present, material easily crushed, when tempered there was a strong clay odour, plasticity and drying shrinkage both low. When burned at cone 06 trials were a faint pink, then nearly white at cone 02 and into a grey buff at cone 9 with fine specks showing. This clay burns off shade for whiteware but should prove useful to blend with more plastic clays for brick, terra cotta, sewer pipe, structural tile and other wares, if washed the clay portion might prove useful in heavy pottery.

2615—This is a sample of the middle beds in the deposit, it is nearly white in shade, some iron stain in places plus very fine oolitic iron which is fairly common. Some zones of the bed are more plastic than others, the latter being gritty, the fracture is earthy and the clay breaks out in blocky form. It has good plasticity, drying properties only fair due to the presence of extremely fine colloidal like material. At cone 06 it develops a light pink shade, then to a very light cream at cones 02 and 3 and finally to a light buff with many specks at cones 7 and 9.

The general uses for this clay would be other than for whitewares, such as in face brick, and structural tile, sewer pipe, possibly in some lower grade refractories like saggers or stove tile if well diluted with suitable grog. Clay No. 2613 is very much the same type of clay.

2617—This is a sample of the greyish, purple plastic clay at the top of the main deposit, that is from the white clay No. 2615 up to the thin lignite seam. It is a fine grained ball clay, the upper three feet being free of iron concretions, these are very common in the lower part of the bed, for the most part they are one inch or more in diameter, of odd shape, many as coils, they are not uniformly distributed. The plasticity is high with a degree of stickiness. The water of plasticity was 33 per cent. and the drying shrinkage 9 per cent. It was light pink at cone 06, changing to white at cone 02 and remained white at cone 9, though there were large dark specks. This is a ball clay and to use it as such it would have to be washed to remove the iron impurities. The large iron concretions would prove objectionable for all other classes of ware, but their removal might be possible. The upper 3 feet of the deposit which is free of iron concretions should prove to be a high grade ball clay for whiteware, especially where a pure white is desired.

Overburden—0-15 feet.
Lignite—2 feet.
2620—6 feet.
2619—5 feet.
2618—2 feet.
Silty Clay—3 feet.
Sandy Clays—? feet.

Location—E.½.—12-8-29w2. This deposit is about 1 mile north of the Medalta pit near Willows.

Sample No.

2618—This is a thin bed of dark chocolate-brown ball clay, is fairly fine grained, has a dry earthy texture, the plasticity just fair. Its burned shades of buff would rule it out of whiteware unless washed and blended with lighter burning clays. At cone 9 it develops a cream-buff and a few specks. It might find use in heavy pottery, sanitary ware, sewer pipe, brick and other structural wares if properly prepared. It could well be blended with clays 2619 and 2620 which are above it.

2619—This is a greyish ball clay which has a purplish tinge when damp, it is fine grained, earthlike in texture and loosely consolidated. It worked up fairly well as to plasticity and dried safely. Its burned shades are practically the same as clay 2618 other than somewhat darker at cones 7 and 9, at those cones there are dark specks. This clay would have to be washed before use other than for heavy clay products. Its uses would be the same as for 2618, they should with the upper clay 2620 be worked together as one clay for most purposes.

2620—This sample is of a greyish shade near the top then changes to a yellowish-white with iron stain in the lower two thirds of the bed. There are some dark stem or tap root remains present, it is of an earthy texture, loosely consolidated and fine grained. Its working and burned properties are so near like those of 2619 that further description is unnecessary.

Overburden 10-15 feet.
Lignite—6 inches to 2 feet.
2622—6 feet 9 inches.
Grey silty bed—3 feet.
Lignitic—1 foot.
2621—7 feet.

Location—N.E. 1-8-29w2. This is the Medalta pit, about two miles north east of Willows.

Sample No.

2621—The general colour of this bed is a greyish-white with black tap root remains, it is sandy, both coarse and fine grained, the latter zone is of a darker shade. The structure is blocky, when tempered there was a strong clay odour. The plasticity was quite good and the drying was safe. Its burned shade at all cones was a dark cream or buff with very fine specks at the higher cones. It is not a ball clay and not suitable for whitewares. Its chief value would be with other clays for structural wares, sewer pipe, fire proofing, terra cotta, etc.

2622—This clay is a ball clay and as sampled composed five bands of clay varying in shade from a grey at the top through a zone of iron concretions (discarded) and to dark greyish-chocolate at the bottom near the silty clay bed. There are some whitish specks or particles in the upper part of the deposit and some dark stem-like streaks near the bottom. The mixture was highly plastic though a little sticky, the drying had to be slow to avoid cracking. At the lower cones it burned to light cream and then to a good white at the higher cones, and was nearly speck free. This clay is of real promise as a ball clay for use in whiteware and other products where ball clays are used in the body mixture. It is one of the better clays sampled during the 1926 field work.

Overburden 4 to 15 feet.
2624—4 feet.
2623—? feet.

Location—N.E. 30-7-28w2. On the Carswell property, south side of valley east of Willows.

2623—This sample was taken from a shallow excavation made in the kaolinized sandy white clay of the Whitemud, the quartz and other sand grains were rather coarse, the general shade was grey plus a whitish powder (kaolin). There was some stratification noted, and, a strong odour of clay when tempered, the plasticity was low, the mass rather sandy or gritty and was of low drying shrinkage. When burned there was a pink shade up to cone 02, above that cone to cone 9 the shade was a light grey buff or cream with a few specks showing. This clay would be unsuited to pottery other than through washing to recover the kaolin portion. In its natural condition it would have to be blended with more plastic clays or shales in order to make it useful for structural wares and other products where a medium dark shade would not prove objectionable.

2624—This clay deposit was under development at the time of sampling, several carloads having been shipped out as a ball clay for use in the production of white dinnerware in the States. Where dry it was grey in shade with a faint purplish tint. It was very fine grained and highly plastic and had to be dried slowy. Its outstanding property was that of burning white at all heats and its freedom from specks. Its chief use is that of a ball clay in whiteware and other bodies like sanitaryware, terra cotta, as a bond clay; it is too refractory for use as a brick or other structural wares clay. It like 2617 an 2622 is one of the higher grade clays collected during the season's field work.

Sample
No.

Overburden up to 20 feet.
Lignite up to 3 feet.
2627—4 feet.
2626—4 feet.
2625—14 feet.
Greyish sandy bed—? feet.

Location—E.½. 24-7-29w2. In a coulee near the coal mines about 2 miles south east of Willows.

2625—This is a typical kaolinized white sandy clay of the Whitemud and has the same general properties and uses as are those of 2623 previously discussed and will therefore not be further dealt with.

2626—This clay is light grey in shade, is slightly gritty, there is iron stain on some of the bedding planes, also small grains of dark mineral or sand, and tap root or plant remains. It has a nice degree of plasticity and worked well, dried safely. At cone 06 it was light pink, at 02 and cone 3 it was a light cream and then changed to a light greyish buff with some specks at cones 7 and 9. It is not a good type of ball clay but when washed it might find use in the lower grades of whiteware pottery, in yellow ware and stoneware, terra cotta, sanitary ware, face brick, sewer pipe and coloured floor tile or quarries, and might be tried for saggers. It occupies the same position in the Whitemud beds as does clay 2616.

2627—This is a dark chocolate clay just below a lignite seam, it is very fine grained, as indicated by its 40 per cent. water of plasticity and a drying shrinkage of 14.4 per cent. and was therefore very difficult to dry safely. Its bonding strength was high which indicates possibilities for its use along those lines. Its burned shade is that of a light cream, especially when washed, which for this clay's use in pottery will be necessary. It may also be considered for use in saggers and low heat duty refractories as a bond clay, also for face brick, terra cotta, sewer pipe and other sanitary wares. Back from the valley front the depth of the bed may be found to be greater than that sampled.

Overburden up to 30 feet.
2631—12 feet.
Lignite—1 foot.
2630—4 feet.
2629—5 feet.
2628—4 feet.

Location—S.W. 30-7-28w2. This outcrop is on the Lonsdale quarter, a mile and a half east of Willows and on the south wall of the valley.

Sample
No.

2628—This bed of clay is the lowest one sampled; it is composed of dark grey sandy material, rather coarse grained plus a whitish powder (kaolin). There are both light and dark grains plus some mica. While blocky the bed as a whole is laminated. When wetted there is a faint odour of clay. Its plasticity and working properties are rather low due to its sandy condition. The drying shrinkage was in consequence low. At all cones from 06 to 9 the burned shade is that of a light grey plus a few specks at the higher temperatures. The ground mass is nearly white and shows less impurities than clay 2623. Like that sample the present one is the kaolinized sandy member of the Whitemud.

2629—This is a dark grey clay with numerous dark tap root remains, it is fairly fine grained though it feels gritty, the fracture is semi-conchoidal and laminated, there was no iron stain or small iron specks or concretions. It worked easily when tempered, the drying

shrinkage was 10 per cent. The burned shade or colour was a light buff at all heats up to and including cone 9, and was nearly free of specks, a washed sample was wholly free. It is off shade for whiteware, but would prove suitable for heavy pottery like yellow ware, stoneware and some sanitary ware, face brick, sewer pipe, structural tile and fire proofing, and for use in certain refractories.

2630—This sample was a blend of yellowish and grey clay, somewhat shaley in structure, though rather loosely consolidated, evidence of small concretionary iron present. The clay is fine grained but is not greasy like many ball clays. It developed a good degree of plasticity and dried safely. At cone 06 it produced a light red and then changed to a light cream up to and through cone 7, where a few specks appear. At cone 9 the shade is much deeper and the specks numerous and larger. Its general uses would correspond with those of clay 2627 described above, though unless the other clays above it could be made use of so that it would be uncovered, then it holds little of further interest.

2631—This is a zone of shales and silty material, of a slightly yellowish-green tint, it is loosely consolidated and is somewhat gritty. It has a high degree of plasticity and proved to be a little sticky. While it dried safely in small trials, it would most likely crack in full sized brick or other wares. It differs from the other samples taken at the same deposit in that it is red burning and does not belong to the Whitemud. The shade of red is of a high order and it fires at low temperatures suitable to red wares, other than for the deep overburden it would be of interest for face brick and other wares made from red burning clays and shales. It is most likely that it would have to be used with grog or sandy clays in order to reduce its high drying and total shrinkage.

Overburden—20 feet.
2632—6 feet.
Base Concealed.

Location—Taken from a small pit opened in a coulee about one half mile west along No. 13 Highway from Willows. A carload of this clay was shipped to Medicine Hat, Alberta.

The sample taken at this point was that of kaolinized sandy white clay of the Whitemud, the full depth of the bed could not be determined. It was quite coarse in texture, composed of both light and dark grains plus the usual white powder of the kaolin portion. There was some iron stain, it crushed easily, its general properties and uses are those of samples 267 and 2623 other than the burned shades are very much darker.

Sample No.
Overburden—30-40 feet.
Lignite—2 feet.
Concealed .....
2635—8 feet.
Concealed .....
2634—5 feet.
2633—30 feet.

Location—S.E. 17-6-22w3. This deposit and others are located one half mile south of the elevator at Knollys.

The outcrops on the above quarter section appear snow white from a distance, they are among the most prominent in that general area, both as to the extent and thickness of the Whitemud, at one point upwards of 40 feet are exposed. The greater part of the beds, however, are composed of the kaolinized coarse sandy members, the light or white plastic beds are much thinner than elsewhere in the Frenchman Valley.

2633—This sample was that of a composite blend of the upper 30 feet of the nearly white sandy beds, the grains being medium coarse plus the white kaolin powder as the matrix. The material as a whole breaks out in blocky form and it crushes easily. There was a strong odour of clay when tempered. All of its working properties were those common to sandy clays of its type like 267, 2623, 2632 before dealt with. This clay as sampled could not be used alone for wares but would prove useful to reduce the plasticity and shrinkage of the associated more plastic clays, both those of the light burning type and the lower grade red or dark burning shales above. Studies regarding the washing of the clays and sands composing this sample are to be recommended in order to determine the kaolin yield and its fitness for use as a paper clay and as the kaolin portion in certain bodies provided it burns white or nearly so. The mixture as sampled burned fairly white up to cone 9 at which point numerous black specks were present. These were partly removed by washing through a 65 mesh screen, the loss in weight was 5.7 per cent. The clay then had a refractory value of a No. 2 grade, about cone 29.

2634—This was the semi-plastic bed above the sandy zone below, the upper part was nearly white and more plastic than the lower half. There were some dark impurities present though not in abundance. The structure was blocky though well laminated. The sample proved a little more difficult to crush than 2633; when tempered it proved to be a little more plastic than that sample but was not quite as free working as could be desired. It dried safely and at cone 06 was of a light pink shade, then changed to buff or cream shades up to cone 9. When washed it was practically speck free. For use this sample would require an addition of a more plastic clay, or like 2633 it could be used as a grog or diluent to a plastic clay, particularly those used for sewer pipe, yellow ware and stone ware, though in the two latter the mixture would have to be washed to remove impurities and some of the larger size quartz grains.

Sample No.

2635—This material sampled as a bentonite and therefore not tested as a clay for industrial use.

2636—This sample was taken on the S.E. 18-6-22w3, at a small butte about one half mile west of the three samples just discussed. It consisted wholly of the sandy white beds. Its properties and uses correspond very closely with those of 2633 and 2634 such that further reference is unnecessary.

Overburden—10-30 feet.
2638—15 feet.
2637—8 feet.
Concealed .....

Location—S. 36-6-22w3. This deposit is known as the Day pit and is one mile north west of Eastend.

2637—This is the lower bed which is light to nearly white where dry; it is plastic though a little gritty and carries dark tap root markings. It developed a fair degree of plasticity and worked well, dried safely and at cone 06 was a clear light shade of cream which gradually darkened to cone 5 followed by bluestoning at cones 7 and 9, and was free of specks at all cones. It is a typical stoneware clay and is in daily use for both yellow ware and stoneware. This clay is improved in its working properties through the inclusion of an associated slightly more siliceous clay.

2638—This is a composite sample of the darker beds above the last sample; in general it is greyish, carries dark grains and tap root fillings or remains. The fracture is semi-conchoidal to nodular structure. Some zones are slightly gritty, others more plastic. It worked well and the drying in small pieces was safe. When burned it proved to be a little more refractory than the last sample in that it did not bluestone or become so dense at the higher heats. The burned shades are lighter but differ in that there are dark specks from cone 3 up. It would have to be washed. It is like the clay beneath it, a stoneware type of clay and can be used for all heavy pottery, in sewer pipe, face brick and other structural wares.

Overburden—0-100 feet.
Concealed
coal-silts shale.
2639—2-4 feet.

Location—S.E. 1-7-22w3. This deposit is near the mine entry at the Ferris mine about two miles north west of Eastend.

This sample is a yellowish-green bentonite which occurs in the zone which lies between the coal above and the Whitemud beds below. It is to be reported on in later work in connection with bentonites.

Overburden—20-30 feet.
2641—9 feet.
Sandy bed, unsampled—9 feet.
2640—4 feet.
Unsampled.

Location—S. 7-7-21w3. This is the Medalta pit about one and one half miles north of Eastend.

Clay 2640 in this deposit has been in use for several years by the Medalta Pottery Co. Ltd. of Medicine Hat in their manufacture of yellow ware and stoneware, though some of the more siliceous clay above it used to reduce the shrinkage and increase its burning temperature to better suit the slip glaze in use. The present laboratory tests indicated it to have high plasticity and a little too much drying and burning shrinkage. When burned at cone 02 it was of a nice light cream shade, no specks, at cone 3 a dark buff and some specks, bluestoning started at cone 5 and was complete at cones 7 and 9 with specks enlarged. This clay should be washed. It may be used for those wares listed under clays 2637 and 2638.

2641—This sample is a mixture of two seams of clay which were being discarded with the overburden material, the lower part being 5 feet of a greyish clay and the upper 4 feet of a chocolate brown clay-like shale with dark patches or colouring along cleavage lines. The general fracture of the bed as a whole is conchoidal and fine grained. It was quite plastic and somewhat sticky; it could be improved in this respect by additions of clay from the sandy bed just below it. The drying and per cent. of shrinkage would also be improved at the same time. In the burn it proved to be a little more refractory than clay 2640 though it does not develop as desirable shades as that clay. It changes from a light buff at cone 06 to a reddish buff at cones 5-7 and 9, with many black specks. There was no evidence of bluestoning. The mixture of the two clays as sampled has the properties of a stoneware clay, though it would be improved through the addition of clay 2640, and it should be washed other than for its use in heavy clay products. From the present tests and results obtained the clays represented by this sample should not be wasted as at present. It can well be considered for use in face brick, sewer pipe, fire proofing, terra cotta, saggers (for low temps.) and other wares as well as heavy pottery.

SUMMARY

In a preliminary classification of the several samples they may be grouped as follows:

269	2622	Likely of use in all classes of whiteware, glass pots and general
2610	2624	bond clays.
2614	2626	
2617	2629	

Light Grey burning.

268	These clays may find use in certain lines of pottery, sanitary ware, terra cotta,
2612	floor and wall tile and face brick, pipe, and saggers.
2615	
2627	
2638	

Dark Grey burning.

2611	This group is made up of clays high in iron concretions or specks, but if washed
2613	may improve in shade and be of the same use as group just above.
2619	

Buff Burning.

261	2618	These clays are of the yellow and stoneware type and may find use
262	2637	for terra cotta, face brick, pipe, floor tiles, modelling clays and
263	2640	possibly in saggers.
264		
265		

Dark Buff burning.

2630	Uses much the same as group just above.
2641	

Sandy or Semi-Fire Clay Types.

266	2628	These clays may possibly prove of value as low grade refractories,
267	2632	or in use with highly plastic clays to reduce their shrinkage, or
2616	2633	possibly washed to recover the clay substance contained in them, and
2621	2634	a still further use would be in a sewer pipe body mix.
2623	2636	
2625		

Red burning.

2631	For heavy clay products like face brick, quarries, roofing tile, pavers and red pottery.

1927 — 109 SAMPLES COLLECTED

Object of 1927 Field Work:

1. To establish if possible the general area limits of the light burning ball clays.

2. To collect preliminary samples of clays likely to prove suitable for yellow ware and stoneware.

3. To collect preliminary samples of the sandy white clays to investigate the advisability of a major study on them regarding their kaolin content and uses for same.

4. To collect samples of clays of the refractory type.

5. To collect a few samples of red burning clays associated with any of the other clays being sampled.

6. To collect samples of volcanic ash for use in research work by the Chemistry Dept. of the University.

The season's work materially extended the known occurrences of the ball clays from those near Willows-Readlyn and those mid-way between Verwood and Willowbunch. Samples of these clays were collected for the first time from the Big Muddy Valley, and, to the west and north west of Twelve Mile Lake, also in the Blue (Cactus) Hills south of Moose Jaw. It is therefore now known that there are large areas and quantities of ball clays in the province. A large amount of detailed work both in the field and laboratory will be necessary to determine the areas, the deposits, and the individual beds of greatest interest for development, and their uses.

Of the total number of the 1927 samples collected, approximately 25 per cent. were of the yellow ware-stoneware type thus indicating large quantities of clays of this type in the province, quite widely distributed in the most southern part of the province. A recommendation is made that they be made the subject of a special report.

Of the white sandy clay samples collected, preliminary washing tests proved them to be quite variable as to their kaolin yields, the same ranging from as low as 10 per cent. to a maximum of 55 per cent. In view of the findings a major investigation was considered advisable and was recommended.

While no exceptionally high grade refractory clays were discovered, a fairly large number of the samples collected as a whole were possessed of refractory properties in so far as fusion was concerned, ranging from semi-refractory to No. 2 grade.

The red burning clays were for the most part found to be weak or poor in their drying properties, that is, cracking when molded stiff mud. Further field and test work recommended.

Of all samples collected it was found possible to group them into six general classes as follows:

1. White to light cream when burned.
2. Light cream to buff when burned.
3. Buff to stoneware grey when burned.
4. Fine grained sandy clays.
5. Coarse grained sandy clays.
6. Red to brown when burned.

1st group.

In this group there are about twenty clays, examples being Nos. 273-277-2728-2742-2779 etc. Some of this group will have to be washed to remove particle size impurities which otherwise would develop as specks in the burned ware. While it is to be understood none of these clays can be used alone they are necessary in the body mixtures of wares like the following: all whiteware pottery such as dinner ware, art ware, porcelain, electrical insulators, wall and floor tile, some sanitary wares, and other wares where whiteness is desired.

2nd group.

The clays of this group, numbering about 25 in all, are only different from the first group in their burned colour or shade. They cannot be used where a good white is desired. Examples are clays 2725-2730-2734-2776 and others. While some of these many not find wide use as ball clays, they may be of equal importance in some cases as bond clays, sagger clays, in sewer pipe, structural wares and other wares where burned colour is not of major importance.

3rd group.

These clays are for the most part of the stoneware type which burn much too dark for use in whitewares. While they burn to light or yellow shades at the lower heats the majority of them develop the typical stoneware grey or bluestone at the higher heats. Their general uses are even greater than those of the ball clays in groups 1 and 2, in that they are useful in all heavy pottery like yellow ware, stoneware, some art ware, terra cotta, floor and fire place tile, face brick, fire proofing, sewer pipe and other sanitary wares. There are sixteen of the 1927 clays in this group; examples are clays No. 2748-2749-2785-2788-2795 and others. They are more abundant and more widely distributed than are the clays of the two preceeding groups.

4th and 5th groups.

While there are wide variations in the grain sizes within each of these groups it was also noted that there are changes in sizes within the same beds or deposits such that intensive detailed sampling will be necessary for a complete study of these clays. Examples of the finer grained ones are clays 2712-2715-2753 and 27101, while those of coarser sizes are clays 274-2717-2764-2774 and others. Studies to date indicate the latter, that is the coarser grain size sandy clays, to be the ones most likely to produce a fair per cent. of kaolin.

In general the uses for the clays of groups 4 and 5 will be that of reducing or controlling the shrinkage of those clays which have the same above safe limits, in such wares as heavy pottery, sewer pipe, terra cotta, all structural wares, for some refractories, and when washed, if sufficiently free of grit and are white enough then there may be use for them in paper manufacture, also if the recovered kaolin following washing is light or white and speck free when burned, then its use in all grades of whiteware may be possible.

6th group.

These are the heavy clay products types of clay where red or shades of same are permissible, like in common and face brick, structural tile, roofing tile, floor or quarry tile, drain tile and low grade pottery like flower pots and some art ware. Clays Nos. 276-279-2751 and 2797 are of this type; their chief disadvantage is that of excess drying shrinkage when molded in the plastic. For some wares the dry press method would overcome that difficulty to a large degree.

The work during 1927 has brought to light the occurrence in Saskatchewan of many deposits of useful clays, some from areas not before known to contain useful clays, particularly those of the ball and stoneware types, those clays which in a major way will eventually be the means of Saskatchewan attaining a high position in the field of ceramics.

By means of the preliminary samples and tests the poor or undesirable clays can be detected and thus ruled out in the matter of any further attention; it is by means of the primary tests that much valuable time may be saved in the field and laboratory work.

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
270	10 ft.	6–10 ft.	Light red	Dark red	Fused	S. 7-8-28w2 Coursalls' quarter sec.
272	4 ft.	10–30 ft.	Light cream	Grey white	Grey white	S. 1-7-29w2
271	3 ft.	10–25 ft.	Light pink	Light cream	Light cream	S. 1-7-29w2 Medalta pit
273	4 ft.	mined	Light pink	Very light	Nearly white some specks	S. 21-7-28w2 Smith's quarter sec.
275	10 ft.	10–15 ft.	Light Pink	Very light	Nearly white some specks	S. 5-8-28w2
274	6 ft.	10–25 ft.	Light pink	Light cream	Light cream some specks	S. 5-8-28w2 On north side of valley N.W. from S. 33.
276	6 ft.	30 ft.	Light red	Dark red	Overfired	S. 6-7-27w2
278	12 ft.	40 ft.	Light cream	Very light cream	Very light cream	S. 12-6-28-w2
277	6 ft.	40 ft.	Med. cream	Light cream	Light cream a few specks	S. 12-6-28w2 Between Verwood and Willowbunch.
279	23 ft.	20 ft.	Light red	Dark red	Overfired	As above though from a different outcrop.

270—This clay is quite sandy and was overfired at cone 4. Can be considered for brick but needs more plasticity.

271—A greyish sandy bed at base of pit. Some tap root remains, medium grain size, considerable kaolin present. Too impure for whiteware, best use that as a grog to more plastic clays.

272—This clay rests on last sample, somewhat sandy but has good working properties, some fine dark specks, still porous at cone 8, might be of interest for saggers, fire proofing, and in sewer pipe and stoneware with other clays. Ball clay 2622 is above these two clays When mixed they are clay 2621.

273—This sample was taken at a small mine entry in the ball clay, the total depth unknown. When washed all specks were removed and the shade improved as to whiteness. This clay is of promise as a ball clay, the deposit should be fully checked for quantity and uniformity of quality.

NOTE:—The exposure of these beds (274, 275)is very poor.

274—This is a kaolinized sandy white clay, rather coarse grained. It corresponds to clay 2621, see it for uses.

275—This clay is a ball clay and checks very closely to clay 273 in its burned shades and properties See notes re that clay.

276—This is a bed of iron stained shale resting on a bed of highly ironized sandy clay three feet thick, not sampled and is at the top of clay 2614. The present sample while slightly sandy has good working properties and burns to nice shades of red up to cone 2. It offers promise for brick and structural tile, and in other red ware not requiring a high degree of vitrification.

277—Is an average blend of samples 268 and 269 of last year. It is a ball clay and its uses would be for those purposes where such clays are required. It should be washed for best results.

278—Is an average blend of 2610 and 2611 of last year, the iron zone between them was discarded. This clay is a ball clay which burns to lighter shades than 277, but contains more iron specks. Washing removed all specks and the shades were much lighter.

279—This is a sample of the shale beds above the ball clays and the first lignite seam. The beds are well stratified. It is more plastic and sticky than clay 276. The present sample cracked during drying. It would require special treatment if developed for red wares.

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES—Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
2710	6 ft.	30+ ft.	Light pink	Light cream	Light cream some specks	S. 35-7-26w2 On north side of valley N.W. of Readlyn
2712	8 ft.	10–40 ft.	Light pink	Cream	Light cream Few specks	S. 9-6-1w3 On the north side of Twelve Mile Lake.
2711	10 ft.	10–40 ft.	Light pink	Cream	Light cream Few specks	
2713	10 ft.	4–10 ft.	Light cream	Yellowish	Light cream Specks	S. 2-11-28w2 On the east side of Lake of the Rivers, south of Mitchellton.
2716	2 ft.	10–30 ft.	Light cream	Light cream	Light cream Very few specks.	Same location as above other than one quarter mile to the north.
2715	2 ft.	10–30 ft.	Pinkish	Light cream	Light cream	
2714	6 ft.	10–30 ft.	Deep pink	Deep cream	Med. cream	
2718	3½ ft.	13 ft.	Light cream	Yellowish	Deeper yellow	N.E. 31-12-22w2 About three miles north east of Avonlea along Avonlea Creek.
2717	3 ft.	10 ft.	Yellowish grey	Greyish white	Greyish white	
2719	10 ft.	14 ft.	Deep cherry red	Dark red	Overfired at cone 2	Same location as above, only at a near-by outcrop up stream.

2710—This is a sample of clay taken from a small abandoned pit. Both ball and sandy white clays present. Beds appear to have been disturbed. Should be carefully checked if considered for use.

2711-2712—These two samples are practically the same other than 2712 is yellowish and slightly coarser grained. They are both members of the sandy white, Whitemud, and their uses in general would be the same as for 271.

2713—This is a sample of greyish white sandy clay of the Whitemud. It has the usual properties and uses of the kaolinized beds of the Whitemud.

2714—Corresponds so closely to sample 2713 that further comments are unnecessary.

2715—Is a thin bed of nearly white, sandy clay of the Whitemud. Should be worked with clay 2714.

2716—Is a purple plastic ball clay not unlike those near Willows at the south end of the lake.

2717—Is that of a very coarse grained bed of the kaolinized sandy Whitemud. It is very short and could not be used alone. Might be of interest for kaolin recovery.

2718—This is a dark purple plastic ball clay one foot above the last sample. It is a typical ball clay and should be further tested as such. Its burned shade at cone 8 is a little too deep for some whiteware.

2719—This is a sample of a conchoidal grey shale in the beds above the Whitemud, and is under bentonitic, silty clays. It was highly plastic, too sticky and cracked during drying. Its colour at the lower heats is good. It is of doubtful value.

2720—This is a heavy seam of kaolinized sandy clay at the base of the pit, is coarse grained and appears to carry a high per cent. of kaolin. Used in some refractories and to reduce shrinkage in other wares.

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
2723	2 ft.	10–25 ft.	Nearly white	Light cream	Cream	S. 28-12-24w2. Local clays in pit of the Dom. Fire Brick and Clay Products Ltd., Claybank.
2722	4 ft.	10-25 ft.	Light pink	Light cream	Med. cream specks	
2721	4 ft.	10–25 ft.	Light cream	Little darker	Light cream specks.	
2720	20 ft.	10–25 ft.	Nearly white	Nearly white	Grey-white	
2728	10 ft.	0–30 ft.	Nearly white	Very light cream	Light cream Few specks	S. 19-13-26w2. This deposit is on the east face of the Blue Hills (Cactus Hills) about 13 miles N.W. of Claybank. Deposit not under development.
2727	6 ft.	0–30 ft.	Pink	Dark cream	Dark cream specks	
2726	3 ft.	0–30 ft.	Light pink	Med. cream	Med. cream	
2725	6 ft.	0–30 ft.	Nearly white	Med. cream	Light cream	
Not taken	2 ft.	0–30 ft.				
2724	12 ft.	0–30 ft.	Light cream	Med. cream (greyish)	Med. cream (greyish)	
Not taken	6 ft.	0–30 ft.				

2721—This is a seam of white plastic refractory clay which occurs just above 2720. It has the general properties of a ball clay, but is lenticular and not everywhere present. It is used both in refractories and face brick. Little change in shade when washed.

2722—This clay is greyish in shade, is fine grained and highly plastic and of excessive shrinkage. It is of the ball clay type and cannot be used alone, for whitewares the black iron specks in the burned ware would prove objectionable, its chief use is for refractories.

2723—This is a black plastic clay which occurs at the top above the other three clays of the deposit. It is very fine grained and highly plastic, can only be used as a plastic or bond clay in certain wares where ball or fire clays can be used. Unfortunately there is not very much of it.

2724—This sample is so near like 2720 that further description is unnecessary. It is at the bottom of the deposit. A kaolin recovery test would be of interest.

2725—This clay is sandy though finer grained than 2724 just below it. There are markings of black stems or roots present. On the whole it is very much like clay 2621 of last year, and its uses would be in general the same, that is for blending with more plastic refractory or semi-refractory clays for sewer pipe, fire proofing, some refractories, face brick, etc., and if washed possibly in heavy pottery wares.

2726—This clay is a dark grey when dry, is rather high in fine silica and some mica. The working properties are fairly good, it should prove useful in some body mixes for some refractories, sewer pipe, terra cotta, face brick and other wares.

2727—This seam of clay is not so refractory as those it is associated with both above and below. It is semi-gritty, worked well and dried safely, burns to a strong pink at cone 06 and to dark cream or buff with specks at cones 4 to 8. Its uses may be considered the same as those of 2726.

2728—This clay is highly plastic and fine grained, it is of a plastic fire and ball clay type. It cannot be used alone for any wares but is suitable as a bond clay in refractory wares, such as fire brick and saggers, sewer pipe and some structural wares, or if washed it could be used in various lines of whiteware. Its depth of bed is of interest.

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES—Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
Lig-nite	1 ft.	30–40 ft. of un-known overbur-den				S. 1-13-26-2. This deposit is in the Blue Hills N.W. of the Wheeler ranch buildings.
2731	3 ft.		Cream	Nearly white	Nearly white	
2730	3 ft.		Nearly white	Nearly white	Light creamy white	
2729	7 ft.		Nearly white	Greyish white	Greyish white specks	
Rusty Sandy Clay not taken	3 ft.					
Lig-nite seam 2732	1 ft.	0–6 ft.	Light cream	Yellowish	Med. cream specks	S.W. 31-7-27w2. On the Noble quarter, three quarters of a mile north of Read-lyn.
2733 Pit No. 2	1½ ft.		Nearly white	Light cream	Light cream	
2734	3 ft.	0–6 ft.	Light cream	Yellowish	Med. cream specks	
2735	4 ft.		Fairly white	Light cream	Med. cream	

NOTE:—The outcrops where these samples were taken are not well exposed and for that reason the thickness noted for the beds may be too low. (Samples 2729, 2730, 2731)

2729—This is a typical sample of the kaolinized sandy Whitemud and holds the same interest as do these clays in general.

2730—This is a bed of grey plastic clay just above clay 2729. It is gritty though quite fine grained. It is a siliceous ball or fire clay and if washed as it would be in a white-ware body mix it might prove useful for that purpose. Other uses would include sagger and terra cotta bodies, sewer pipe mixes, etc.

2731—This is a nearly black, plastic clay which corresponds very closely as to position and in physical properties to clay 2723 near Claybank, and to clay 277 before described. See them for other details.

NOTE:—The four samples from this location were obtained from two test pits dug for the purpose in a branch valley from the north.

2732—This is a chocolate coloured clay just beneath 3 feet of clay-lignite, the working properties were good and its burned shade favourable. Unless it can be found in greater quantity than that of 1 foot depth it is of no further general interest alone, but could be included with clay 2733 just below it.

2733—The shade of this clay is very light, nearly white, it was nicely plastic, though a little silty. A few selenite crystals were noted. Its burned shades are those of a ball clay. Fur ther prospecting advisable.

2734—The colour or shade of this clay is bluish, it is slightly gritty such that it molded easily and dried safely. There were specks from cone 4 up but when washed they were removed. The burned shade at the higher temperature is satisfactory for heavy pottery, and the clay offers uses for sewer pipe, structural wares and possibly for use in saggers. Further prospecting necessary.

2735—This clay is bluish-grey in shade, is a little more sandy than clay 2734 just above it, the working properties are all good. The burned shades are a little darker than the clay above it, the two clays could no doubt be blended for use thus making a workable seam of 7 feet or more. This deposit is a little below that of clays 2732 and 2733.

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES—Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
2741	4 ft.	0-15 ft.	Nearly white	Light cream	Light cream	S.W. 3-8-29w2. On the Simmon Quarter about 1 mile north west of Willows.
Lig-nite	4 in.					
2740	3 ft.		White	Dark cream	Overfired	
2739	2 ft.		Nearly white	Creamy white	Creamy white few specks	
2738	6 ft.		Nearly white	Creamy white	Grey white	
2737	6 ft.		Pink	Dark cream	Greyish-buff specks	
2736	20 ft.		Salmon	Brownish	Grey-red	
2743	6 ft.	5-30 ft.	Good red	Overfired	Overfired	S.E. 28-7-28w2. J. Wood's quarter south of the valley and about midway between Willows and Readlyn.
Lig-nite	6 in.					
2742	4 ft.		Light pink	White	White	

2736—This clay is of a buff-grey shade, very sandy and coarse grained, some kaolin, was fairly plastic, dried safely with low shrinkage. Its colour when burned is poor and the body is weak. Its chief use would be as grog to other clays in the same deposit.

2737—This sample is very much like the clay below it, 2736, other than it burns to lighter shades and is more kaolinitic. Its general use would be the same as clay 2736.

2738—This clay is also sandy and carries black root markings. It burns to lighter shades than the clays beneath it. Its use would be as a diluent to the more plastic clays or possibly for kaolin recovery in case the clays above could be used for clay wares.

2739—This is a thin seam of dark chocolate clay, a little gritty from fine grained sands. It worked satisfactorily and burns to shades suitable for use as a ball clay if freed of the fine dark specks. General uses might be in low grade refractories, sewer pipe, terra cotta, face brick, though could be improved if blended with clay 2740 just above it.

2740—This is a lower grade clay than those below it, it occurs as a dark brown shaley clay, fine grained and highly plastic, shrinkage too great for most uses. It has the burned properties of a stoneware clay, it bluestones at cone 4 and is overfired at cone 8. Offers promise for use in yellow ware, sewer pipe, face brick, and other heavy clay products, should be further investigated as to quantity.

2741—This is the uppermost bed of clay in the deposit and is just above a thin lignitic-iron seam. It is not so plastic due to the presence of fine grained sands. Its working and drying properties are good. While it burns to fairly good shades, its general uses would be like those of clay 2739. Further prospecting may find a greater depth of this bed.

NOTE:—These samples were collected from a small shaft which had been sunk for test purposes. (2742, 2743.)

2742—This clay is a bluish-grey when dry, and contains black fillings of past root growth. It proved to be a ball clay and one of the best white burning samples collected during the season. When washed it was wholly free of speck forming impurities. It should find use as a ball clay in all whitewares.

2743—This is a shale-like clay just above a thin lignite seam and is red burning corresponding to clays 276 and 279. Its chief weakness is high shrinkage and a rather short firing range.

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES—Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
Lig-nite	1–2 ft.	0-20 ft.				N.E. 5-6-29-w2. One mile east and a half mile north of St. Victor.
2744	10 ft.					
2745	15 ft.					
Sand-stone	Band	200+ft.				S½. 7-1-22w2 Carlyle Coulee in lower Big Muddy Valley near Montana.
Light silts	3 ft.					
2751	3 ft.		Light red	Dark red	Overfired	
2750	4 ft.		Light cream	Light yellow	Dark yellow	
2749	5 ft.		Light cream	Light yellow	Bluestoned	
Stone	1 ft.					
2748	4½ ft.		Med. Buff	Med. Buff	Bluestoned	
2747	2½ ft.		Light cream	Med. Buff	Overfired	
2746	2 ft.		Light cream	Bluestoned	Overfired	
Stone	.....					
Talus	50 ft.					

NOTE:—Sample 2744 is a white volcanic ash and 2745 beneath it is a bed of silty material not tested as a clay.

NOTE:—This horizon of clays is geologically much higher than is that of the Whitemud in which the ball clay occurs in the east and the stoneware clay in the Cypress Hills. The present clays are of a later deposition and occur in the Ravenscrag of Davis. In case no further zones of light burning clays are found then the present one might be designated as the "Upper Whitemud". (Samples 2746 to 2751)

2746—This clay is dark brown or chocolate in shade when damp. It is very fine grained and greasy when rubbed, is of a semi-conchoidal fracture, has good plasticity, shrinks too much and bluestones rather early at cone 2. Its general use would be with other clays of the same deposit, but not alone for yellow wares, stoneware, face brick, sewer pipe, fire proofing and other wares.

2747—This clay is very much like 2746 other than it is a little lighter in shade and has a well developed conchoidal fracture, its burning properties are better in that it does not bluestone until cone 4. The uses are for the same wares as for 2746.

2748—This is a better type of stoneware clay in that it is more siliceous and therefore works and dries better and more safely. The grain is fine and there is some iron stain. It burns to a nice clear shade at the lower heats and does not start to bluestone below cone 4 and does not overfire at cone 8. It would be useful for all wares listed under 2746.

2749—There is a one foot layer of shaley sandstone between this clay and 2748, it was discarded from the sample, the present clay has a tinge of light chocolate, it is fine grained and has replacements of roots, leaves and stems. It is a stoneware type of clay which does not bluestone below cone 4 and could be used with clay 2750 and 2751 above and theso below it for all wares listed under clay 2746.

2750—This clay is so closely related in all of its properties to the last sample, other than being a little more refractory, that no further comments are necessary. Clay 2749 would be improved by its addition.

2751—There is a sudden change in type of this clay from those below it, in that it burns red, it is quite gritty, has good plasticity and dried without cracking. Its burning properties are not so good in that its vitrification and colour ranges are too narrow, it would require the addition of a more sandy clay for brick and other red wares.

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
Stone	1 ft.	excess				S. 20-2-22w2. In Huntley coulee south of Big Muddy Lake and near the Keough Ranch.
Lignite	Thin					
2755	5 ft.		Light cream	Med. cream	Buff. Large iron specks	
2754	4 ft.		Med. cream	Bluestoned	Overfired	
2753	5–6 ft.		Nearly white	Grey-white	Light cream	
Iron zone	1 ft.					
2752	4 ft.		Pink-cream	Buff	Bluestoned	
Light silts	4 ft.	30–50 ft.				S.E. 4-2-22w2 The deposit sample is located a short distance south of the ranch buildings and corrals.
2758	4 ft.		Light cream	Very light	Cream, specks	
2757	4½ ft.		Light cream	Yellow buff	Deep shade, specks	
2756	20 ft.		Pink cream	Light cream	Light cream	
Valley Floor	200±ft.					

2752—This is the lowest member of the deposit, is greyish-white, semi-gritty, some iron stain and of fair plasticity, dried safely, it is a stoneware type of clay and could be used for the wares possible from clays of that type.

2753—This is a fine grained sandy clay with some iron stain, pronounced clay odour when tempered, good working and drying properties. It is the most refractory and lightest burning clay of this deposit. It should be mixed with them to their benefit.

2754—This is a fine grained plastic clay, rather sticky when tempered, has too much total shrinkage. It is of the stone-ware type but must be blended with a more sandy clay.

2755—When damp is dark in shade, is semi-gritty, has good plasticity and dried safely. The shades for yellow ware are good up to cone 4 and at cones 6 and 8 becomes much darker with large iron spots. Must be washed for pottery wares, not for brick, sewer pipe, terra cotta and other heavy wares.

NOTE:—The clays (2756 to 2758) in this deposit are not of the ball clay type, nor are they the same type as the stoneware clays 2746 to 2751 sampled in Carlyle Coulee, nor are they at the geological level of them, it would therefore seem that there are two horizons of stoneware type clays in the area of lower Big Muddy Valley.

2756—This clay is yellowish to white in shade, it is sandy and rests on large tree-like sandstone concretions. The grain size is fine, plasticity good and drying safe. The burned shades are those of yellow ware though the clay is rather porous at cone 8. Offers uses for all heavy pottery, sewer pipe, terra cotta, structural wares and other lines though not for whiteware.

2757—This sample is of three shades, yellow, red, and green, it has some iron stain. Its properties are practically the same as those of 2755 and the uses would be the same. The raw colours are those common to some paint clays.

2758—The colour of this sample is purplish to chocolate, it is fairly gritty and only fair in plasticity, the shrinkage is low. The burned shades are very light more so than clay 2753 of Huntley Coulee. It gave no trouble in burning and offers promise of use for c.c. ware, all heavy pottery, saggers, structural wares and sewer pipe, etc. The distance from rail greatly reduces the importance and value of all the clays in the lower end of Big Muddy Valley.

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES—Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
2759	1–4 ft.					Location same as above though sample taken a short distance south of clays 2756-2758.
2761	10 ft.	30–40 ft.	Pink	Light cream	Light cream	S.E. 4-2-22w2. North west across valley from where samples 2756–2759 were taken.
Iron ledge	.....					
2760	4½ ft.		Light yellow	Cream, slight bluestone.	Overfired	
Silts	.....					
Lignite	1 + ft.	40 + ft.				S. 34-3-24w2. North bank of Big Muddy Valley about ten miles south of Bengough and a mile east of No. 34 highway
2763	6 ft.		Light pink	Light cream	Light cream	
2762	6 ft.		Pink	Light cream	Light cream Few specks	
Lignite Not S'pld	Thin 12 ft.					
2765	10 ft.		Nearly white	Light greyish white	Light greyish white	
2764	10 ft.		Greyish white	Darker greyish white	Darker greyish white	
S. stone	.....					

2759—This was a sample taken from the same zone or bed as 2757, the interest was that of the strong red and yellow colours plus mixtures of the two. The clay can rightly be called a paint clay but would need washing to reduce the silica content. When tempered the plasticity and drying shrinkage were both good for general use. The burned trials were a brilliant red up to cone 4, brownish at cone 6 and overfired at cone 8. Other than its interest as a paint clay it could best be used to improve the burned red shade of other weak red burning clays or shales.

2760—This clay occurs just below a lignite seam and is purplish to dark grey. It is quite fine grained and has good plasticity and working properties. Drying was satisfactory. When burned it proved to be a stoneware type of clay which bluestoned at cone 6. It has good shades of yellow for yellow ware. Uses all wares for which stoneware clays are employed.

2761—This sample of clay is nearly white with some iron stain. The lower half of the bed is somewhat sandy, the grain being quite fine. All properties were good in the matter of plasticity and drying though when burned the body was somewhat open and porous at cone 8, too much so for stoneware. It would be better if mixed with clay 2760. It may have possibilities for low grade refractories, saggers, sewer pipe and other bodies of like wares.

NOTE:—Beds 2764 and 2765 are below clays 2762 and 2763, with 12 feet of chocolate-grey shale and silts between them, not sampled. Clays 2764 and 2765 were collected at a nearby outcrop to that of the two upper clays. It is well to mention that the Whitemud high grade clays in the Big Muddy Valley are unfortunately at or near the floor of the valley under a total overburden of nearly 300 feet, therefore mining methods would be only the means of recovering the high grade clays. The haul to transportation is somewhat more than could be desired.

2762—This clay contains dark plant remains, some iron stain and has a slight grittiness such that the plasticity and drying were both good. The burned shades are suitable as a ball clay but it should be washed, may have use in some refractories as well as for those of a ball clay.

2763—This clay is dark in shade, finer grain and more plastic than 2762, it is a ball clay and of better quality than 2762. It can not be used alone for any wares.

2764—This is a typical bed of kaolinized sandy Whitemud and is of interest re a source of kaolin and as a diluent to highly plastic clays.

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
Lignite 2611 Iron zone 2767 2766 Talus	2 ft. 8 ft. 10 in. 5½ ft. 3 ft.	30 + ft.	Very light Light cream	Very light Med. cream	Very light Slight bluestone.	S. 12-6-28w2. This deposit is mid way between Verwood and Willowbunch and west of the highway. At the Midland mine.
Lignite 2770 2769 2768 2615 Talus	1 ft. 3 ft. 6 ft. 7 ft. 10 ft. ?	12–15 ft.	Light cream Light cream Light cream	White Nearly white Light cream specks	White Nearly white Light cream specks	S. 33-7-28w2. About mid way between Willows and Readlyn, on the south side of the valley.
2771 2772						From a cutbank at the top of the hill, No. 2 highway, 1 mile south west of Rockglen.

2765—This clay is also a kaolinized sandy white clay like 2764 other than it is finer grained, its properties and uses would be the same.

NOTE:—These two samples (2766, 2767) are from different sections of the beds represented by samples 268–269 and 2610 of last year.

2766—This is the lower 3 feet only of sample 268, and is the darker portion of same. It is a ball clay of lower value than the next sample above it. It does not burn to as light a shade, and it is highly carbonaceous. Could be better used in refractories, sewer pipe and other heavy wares though not alone.

2767—This sample represents the upper 1 foot of 268, and all of 269 and 2610 of last year, a total of 7 feet of ball clay which burns nearly white and therefore possible for use in whitewares, as a bond clay and plasticizer for other clays where necessary. Unfortunately it is under such heavy cover that mining would be necessary.

NOTE:—These three samples (2768, 9,70) represent a more detailed break-down of beds 2616 and 2617 of last year.

2768—This is the lower seven feet of 2617. It is an iron stained grey ball clay which contains fine grained iron as an objectionable impurity other than for its use in refractories, sewer pipe and other heavy wares. Unless it can be greatly improved by washing or other treatment.

2769—This is the middle zone of 2617 of last year, is greyish in shade, and is a ball clay though of questionable value due to the presence of a large number of both small and base ball size iron concretions. If these could be economically removed then the clay which burns nearly white could be used in certain white wares, or blended with 2770 above it.

2770—This is the upper portion and concretion-free portion of 2617. Its general shade is a purplish-grey when damp. It is a high grade ball clay and one which remains white up to cone 14 without any sign of bluestoning. This is one of the more important beds of ball clay so far sampled. In the past several carloads of it have been shipped to potteries in the United States.

NOTE:—These are of no interest as clay samples, one a sample of coarse grained sand and the other a whitish marl ike material fairly high in carbonates. (2771–2772)

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES—Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
2775	2 + ft.	10 + ft.	Nearly white	Light cream	Lighter shade	S. 30-5-2w3. These samples were taken in a coulee south of Twelve Mile Lake and north of the road from Scout lake to Wood Mountain.
Lig-nite	1 ft.					
2774	6 ft.		Light pink	Greyish-cream	Light grey	
2773	6 ft.		Pink	Pink	Greyish buff	
Grass cover-ed	40 ft.					
Lig-nite	2 ft.	12 + ft.				N.½ 27-5-3w3 This.. deposit is west of the road from Flintoft to Wood Mountain and on the Keresh lands.
Cover-ed	5 ft.					
2781	8 ft.		Light cream specks	Light cream specks	Cream Many specks	
2780	6 ft.		Light buff	Lighter shade few specks.	Lighter shade few specks.	
2779	3 ft.		Nearly white	Nearly white	Nearly white	
2778	4 ft.		White	Very light	Very light	
2777	2 ft.		Light cream	Light cream	Med. cream	
2776	5 ft.		Light cream	Med. cream	Med. cream	

2773–2774–2775—These are all kaolinized sandy Whitemud. The two upper beds appear to carry more kaolin than the 2773 and are less stained with iron. General interests are for kaolin yield and mixing with other clays. Their distance from rail will likely prevent their development.

2776—This is a medium grained sandy clay at the base of the outcrop, buff in shade, mica and some dark material present. It has good plasticity, dried safely, general uses in some refractories, sewer pipe, brick, terra cotta and other structural wares, should be blended with lower grade clays for most uses.

2777—This is a thin seam of dark chocolate clay, it is sandy, working and burned properties same as 2776. They should be blended.

2778—This is a greyish-buff very fine grained semi-sandy clay of good plasticity and working properties, it dries safely and burns to a much lighter shade than the two clays below. It is not a ball clay, but a kaolinized sandy clay. Its uses would be much the same as those of 2776.

2779—This is a promising seam of ball clay of semi-conchoidal fracture, burns white and has in general the properties of clay 2770. There are iron concretions at its top to be avoided. It is unfortunate that this high grade clay is below two beds of lower grade ball clays, 2780 and 2781.

2780—This is a seam of iron stained ball clay of blocky structure, greyish-buff in shade, There are iron concretions at and near its base which can be avoided. Other than a few specks and that of not burning quite so white it is very much the same as clay 2779. Further testing should be that of washing and blending clay 2780 with 2779, and clay 2781.

2781—Other than this clay containing more fine grained impurities it is very similar in all properties to clay 2780 just below it. Unless it can be purified then it must be used for other than whitewares. It might well be blended with clay 2776 for heavy clay products.

NOTE:—The cross section of beds here sampled included twenty feet of the upper beds of the Fox Hill, and thirty one and one half feet of the Whitemud plus three feet of the contacting Ravenscrag. The most complete sectioning done in the Cypress Hills area during the season. (Samples 2782 to 2794 incl.)

2782—This was a sample of the yellowish to buff Fox Hills sands, the main object was to determine its burned shades or colour re its use as a diluent or grog to the more plastic beds above. It could not be worked alone being too sandy, nor could it be used as a blend to the stoneware clays above due to its colour being red when burned, though for heavy clay products it could be employed with those clays or others.

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
Bentonitic shale	7 ft.	0–30 ft.				S.W. 25-6-22w3. This section of beds is located near the top of the valley and south of the dam west of Eastend.
Yellowish silts	11 ft.					
Shaley silts	7 ft.					
2794	3 ft.		Salmon	Reddish buff	Deep buff, specks.	
2793	4 ft.		Light pink	Light cream	Light cream, specks.	
2792	3 ft.		White	Very light	Light cream, specks.	
2791	4 ft.		Light cream	Light bluestone.	Overfired	
Iron stain	Thin					
2790	1½ ft.		Light cream	Light bluestone	Overfired	
2789	1½ ft.		Light cream	Deep cream	Greyish	
2788	4 ft.		Yellow	Stoneware grey	Overfired, few specks.	
2787	2 ft.		Very light cream	Very light cream	Light cream, few specks.	
2786	5 ft.		Pinkish buff	Med. Buff	Slight bluestone.	
2785	3½ ft.		Pink	Deep buff	Bluestone, clear.	
Lignitic	8 in.					
2784	5 ft.		Light cream	Greyish	Deeper grey	
2783	3 ft.		Cream	Greyish cream	Greyish	
2782	20 ft.		Light red	Med. red Greyish	Greyish brown	
Shale	? ft.					

2783—This bed is a nearly white kaolinized sandy member of the Whitemud. It is fine grained plus sufficient clay substance to permit of molding but too weak for industrial wares. It burns to the common greyish shades of the sandy white clays, and is still quite open at cone 8. Its use would be with the clays above for the usual wares made from stoneware clays.

2784—Other than for its raw colour, that of a brownish-chocolate shade, it is in all respects the same as 2783 and could be employed with it, or alone, for the same uses.

2785—This bed of clay is just above a thin seam of lignite, it is nearly white and contains more clay substance than sample 2784, it therefore has better working properties, it is one of the better clays in the deposit, it is quite free of specks, and is only lightly bluestoned at cone 6, and does not overfire at cone 8. It is a yellow-ware stoneware type of clay and could well be used for other wares.

2786—Other than being a little more plastic, lighter in raw shade and carrying some speck forming impurities, it is practically the same clay as 2785 and plant washing would improve it greatly.

2787—This is a further seam of useful stoneware clay which can be included with the clays below it, there are a few specks at cone 8. It might be useful in earthenware.

2788—This seam is a highly plastic white clay which would likely crack in full size ware during drying. It burns to a nice yellow at cone 06. It bluestones at cone 02 and it therefore has a short vitrification range. It would have to be blended with more sandy and higher refractory clays to become useful.

TABLES AND BRIEF NOTES ON THE 1927 SAMPLES—Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
Burned shale	4 ft.					S. 18-6-22w3. About one half mile south west of Freels' ranch buildings near Knollys.
Yellow silts	20 ft.					
Buff shales	25 ft.					
2797	12 ft.		Tan	Nice red	Brownish tan	
2796	5 ft.		Pinkish	Light cream specks.	Light cream specks.	
2795	7 ft.		Very light	Light cream clear	Stoneware grey	
Sandy beds						

2789—This is a thin seam of nearly white plastic clay of good properties which does not overfire at cone 8, though is bluestoned at that cone and is quite badly specked. It is too limited in quantity to be used alone, but can well be blended with other clays of the same deposit.

2790—This clay while also a stoneware clay is somewhat defective in that it is sticky when plastic, dry shrinks too much and bluestones at cone 02 and overfires at cone 6. It should be blended with the more refractory clays of the deposit.

2791—This sample while a little more siliceous is nearly of the same kind and quality as the clay below it, 2790 and will require the same treatment.

2792—On fresh exposure this clay is of a purplish tint, not unlike some of the ball clays in the east near Willows. It is highly plastic and can not be used alone. It burns very light and if washed could no doubt be used in some c.c. and earthenwares. Otherwise it is a good grade of stoneware clay to mix with some of the lower grade ones in the same deposit.

2793—This is the uppermost bed of the Whitemud stoneware clays in this deposit. The upper two feet is a grey plastic clay while the lower two feet is of a lighter shade and is more siliceous. Its working properties in the raw are fair, it could be improved through the addition of a more plastic clay, and for most wares one that fires at a little lower temperature. The remarks re clay 2792 just below it can be applied to this clay as well. They could be worked as a single clay.

2794—This is a lower grade clay, dark chocolate in shade, fine grained and a little too plastic and the drying shrinkage higher than desirable for heavy clay products. It stands up well at cone 8, and if blended with other suitable clays would be of interest for sewer pipe, brick, terra cotta, fire proofing, structural ware and other like products.

2795—This is a type sample of the white plastic stoneware clays of the Whitemud. It was nicely plastic though in large ware should have an addition of a more siliceous clay. Its burned shades are good for all heavy pottery like stoneware and some sanitary products. It does not bluestone below cone 4. At cones 02 and 2 it has clear shades of light cream or yellow suitable for yellow wares. Other uses would be for all wares made from this type of clay.

2796—This is a fine grained chocolate coloured clay, is of good plasticity and burns to very good light shades, though specks are present from cone 02 up. It does not bluestone and if washed should prove very useful in several wares. It corresponds in this respect to clay 2792.

2797—This seam of clay is above the Whitemuds, it burns to red and other dark shades unsuited to pottery wares. It is too plastic and has too much shrinkage, might be made useful through additions of the sandy Whitemuds or other siliceous clay.

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
Dark shale	8 ft.	25 ft.				S. 35-5-20w3. This deposit on the north bank of Frenchman River approximately twelve miles south of Dollard.
27102	3 ft.		Salmon	Med. red	Tan, specks.	
27101	3 ft.		Light cream	Light yellow	Very light yellow	
27100	30 ft.		Light cream	Light yellow	Greyish yellow, specks.	
2799	2 ft.		Light cream	Med. cream clear	Med. cream clear	
2798	12 ft.		Light cream	Light yellow	Greyish cream	
Grass covered						
27103						Sample 27104 from near Duncairn. Samples 27103 and 27105 from near Waldeck.
27104						
27105						
27109	10 ft.	5–10 ft.	Yellowish	Cream white	Grey-white	S. 12-21-11w3. The outcrops sampled in this area are about eight miles south of Beechy and about one half mile west of the highway.
27108	12 ft.		Light cream pinkish	Light cream	Light cream	
27107	18 ft.		Nearly white	Light cream	Light cream	
27106	20 ft.		Light cream pinkish	Light grey creamy	Light grey creamy	

2798—This is the lowest exposed member of the beds in this deposit. It is a kaolinized white sandy clay of the Whitemud. It is coarse grained and offers favourable possibilities of a high yield of kaolin if washed. Of little interest for use alone in its unwashed state. This sample like the other sandy members of the deposit develop yellowish rather than white when burned as is common to the sandy white clays below the ball clays to the east.

2799—This is a thin seam of purplish clay, fairly fine grained and of semi-conchoidal fracture. It is of good plasticity and moderate shrinkage and burns to very good light shades. Could be used in several bodies though the quantity is too limited and the bed irregular as to thickness.

27100—This sample is from the thickest bed of the deposit, its properties and interest are those of sample 2798.

27101—Other than for a little difference in shade or colour plus small iron grains and some stain, this clay is not unlike 27100, though it might be well to discard it due to its impurities unless they can be removed economically.

27102—In this case the bed from which the sample was taken is above the Whitemud and does not burn light or white. It is highy plastic, has too much shrinkage and could not be used alone. It is so near like clay 2794 that reference is directed to that clay for uses.

NOTE:—These are samples of volcanic ash collected for the Chemistry Dept. (27103–27105.)

NOTE:—The samples were taken from three outcrops as indicated, they are all within a short distance of each other. There is no doubt some overlapping in the samples as indicated by samples 27106 and 27108. There is no particular need to discuss these samples individually other than 27109, in that they are all of the kaolinized sandy type of Whitemud. Their chief interest would be that of their yield of kaolin for paper clay or in whiteware, provided their properties were suitable for those uses. Their distance from rail and water will most likely prevent their development, especially so in that there are the same types of clay along side of rail.

27109—This bed of sandy Whitemud is unusual in that it is very hard and stone like, quite different to the usual occurrence where the material is either loosely consolidated, or, is somewhat difficult to loosen, but in neither case are they brittle as is the case with the sample bed under question. When crushed, unless very fine, there is a total lack of plasticity, though small trials were molded and when burned the general shades were white. Investigations will be necessary to find uses for this material. It is to be stated that beds of plastic Whitemud were wholly absent in the vicinity of the above deposits.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
281	4 ft.	Black	.....	High	010	High	.....	Red
Overburden	12 ft.							
Lignite								
282	2 ft.	D. choc.	.....	High	010–8	High	.....	Very light
281	8 ft.	Grey						
283	2 ft.	D. choc.	.....	.....	6	High	.....	Very light
Concretions	3 ft.							
Sandy clay	1 ft.	White						
284	2 ft.	D. grey	.....	Good	6	Med.	.....	Light cream
Sandy clay	7 ft.	Lighter						
Lignite	1 ft.							
285	6 ft.	Rusty	.....	Fair	02	.....	.....	Reddish
Overburden	60 ft.	Buff and grey						
287	3 ft.	D. choc.	.....	High	02	High	.....	Dark buff
286	8 ft.	White	.....	Good	6	Med.	.....	Cream
Lignitic clay	3 ft.							
Overburden	60 ft.							
Dark clay	? ft.							
No. 14 clay	3 ft.	White						
288	10 ft.	White	.....	Low	010–8	Low	.....	Grey-white
289	10 ft.	Greyish						
Sandy white clay	? ft.		.....	Good	010–8	Med.	.....	Very light

281—Near Crane Valley. Taken in road cut two miles south and one mile west of Crane Valley. Of little interest.

282–281—S. 27-5-3w3. South of Flintoft.

NOTE:—All samples from 281 to 2821 inclusive were taken as preliminary samples for colour, type and other information only. 282 is a ball clay of promise.

283—S. 27-5-3w3. Taken three quarters of a mile S.W. of 282 and at the same horizon. Is a ball clay.

284—Same outcrop as 283. This sample very light cream at cone 010 to a golden buff at cone 8. The intermediate shades are good. This is a slightly sandy ball clay.

285—S. 25-6-22w3. A small sample of shale from a mine roof cave-in south west of Eastend. Material not very promising.

286–287—S. 34-6-23w3. About one mile south east of Pierre ranch buildings. Sample 286 is a good grade of plastic stoneware clay, it bluestones at cones 7–8. Sample 287 is a lower grade clay though should be more fully tested.

288—S.½. 17-6-22w3. One half mile south of Knollys. This is a sample of the sandy white clay below the No. 14 plastic stoneware clay.

289—S. 13-6-23w3. South west of the Freel ranch buildings. This is a good grade of plastic stoneware clay, does not bluestone at cone 8 but has large black specks.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	12 ft.							
2812	6 ft.		.....	Med.	010–8	Med.	.....	Light to grey
2811	4 ft.		.....	Good	010–8	Good	.....	Light to grey
2810	5 ft.		.....	Low	010–8	Low	.....	Pink to D. grey
Overburden	40 ft.							
2813	8 ft.	Grey	.....	Good	010–8	Med.	.....	Pink to white
Overburden	20 + ft.							
2815	7 ft.	Dark	.....	High	010–8	High	.....	Pink to white
2814	25 ft.	White	.....	Low	010–8	Low	.....	Pink to greyish
Overburden	100 + ft.							
Lignitic clay	3 ft.							
2817	5 ft.	Dark	.....	High	010–8	Med.	.....	Light-M. cream
2818	4 ft.	L. grey	.....	Med.	010–8	Med.	.....	Light-L. cream
2819	3 ft.	Grey	.....	High	010–8	High	.....	White-L. cream
2816 Lignite	? ft.	Grey						
Overburden	100 + ft.							
Lignite	1 ft.							
Clays	7 ft.							
2821	2½ ft.	Very dark	.....	Good	010–8	High	.....	Pink to L. cream
2820	3 ft.	Dark grey	.....	Good	010–8	High	.....	Pink to L. cream
Shale and lignite								

2810–2811–2812—W.½. 27-6-22w3. At a small outcrop one half mile N.E. of the Potter's ranch buildings. Clays 2810 and 2812 are semi-sandy and can be used in part with the more plastic bed 2811 as stoneware clay.

2813—N.W. 19-13-25w3. South of Dominion Fire Brick & Clay Products Co. Ltd., clay pit. Taken about one quarter mile south of the open clay pit. This clay is a light burning plastic fire clay or ball clay, full depth not exposed.

2814–2815—S.W. 19-13-25w3. These samples were taken in the abandoned Wellington white pit. Clay 2814 is a highly kaolinized sandy clay of the Whitemud. Clay 2815 is a dark nearly black ball clay, burns whiter than clay 2813.

2816–2817–2818–2819—S.W. 35-3-24w2. About ten miles south of Bengough on north wall of Big Muddy Valley. Clays 2817–2818 and 2819 are all ball clays of good burned colours, some specks. Would have to be mined. Shale 2816. Sample 2816 missing. It was from a bed of shaley material and would possibly have been of lower quality than the ball clays above it.

2820–2821—S. 34-3-24w2. Taken on north side of Big Muddy Valley about one mile west of highway No. 34. Both of these clays are type ball clays of good burned colour. They are practically the same clays as 2818 and 2819. They would have to be mined.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Clay	10 ft.							
Silts	25 ft.							
2822	10 ft.	Dark grey	35.0	11.0	5	5.2	5.8	Deep cream
2823	6 ft.	Greyish white	24.0	5.0	5	3.7	9.0	Pinkish buff
Overburden	10 ft.							
Lignite	6 in.							
Silts	20 ft.							
2826	4 ft.	Greyish	38.0	9.5	04	7.3	7.8	Light red
Silts	2 ft.							
Lignite	Streak							
2825	5 ft.	L. grey	39.0	14.5	02	2.0	4.0	Deep red
2824	4 ft.	Yellowish	29.0	8.0	02	6.0	7.6	Deep red
Glacial	? ft.							
Lignite	Thin							
Silts	20 ft.							
2833	10 ft.	Yellowish	27.0	6.7	1	2.3	8.7	Nice red
2832	8 ft.	D. grey	29.0	10.0	5	1.5	10.1	Cream
2831	2 ft.	Greyish	36.5	11.7	1	6.8	5.1	Stoneware grey
2830	2 ft.	Black	53.0	16.0	1	10.0	3.1	Stoneware grey
2829	2 ft.	Greyish	37.5	12.0	5	8.0	0.8	Bluestone
2828	5 ft.	Greyish	30.5	8.0	5	3.0	10.9	Greyish-buff
2827	10 ft.	Greyish	18.7	3.6	5	0.4	10.8	L. sandy grey
Unknown								

2822–2823—N.½. 22-5-28w2. About two and one half miles N.W. of Willowbunch. Clay 2822 has good working properties, useful for yellow ware and stoneware. Shrinkage needs to be reduced. Clay 2823 is very sandy and short on plasticity. Might be used to reduce shrinkage of 2822 or other clays.

2824–2825–2826—N.W. 22-5-28w2. This outcrop near that of 2822 and 2823. Clay 2824 has good working properties, shrinkage a little too high, very nice reds cone 07 to cone 1 inclusive. Clay 2825 has too much drying shrinkage, would crack, burned colours are same as 2825, a blend would improve both clays. Use-brick and other red wares. Clay 2826, this clay is very close to clay 2824 in all of its properties, other than it can be burned at lower temperatures.

2827–2828–2829–2830–2831–2832–2833—N.W. 15-5-28w2. West of Willowbunch and south of last samples. Clay 2827 of little interest for use alone, would be useful to reduce shrinkage of other clays in the same deposit. Clays 2828–2832 inclusive are all of the yellow ware stoneware type and could very well be blended as a whole for those wares, face brick, fire proofing, terra cotta, in sewer pipe, etc. Clay 2833 is a nice red burning clay of good colour and vitrification range. It would likely dry safely in full size ware in a suitable dryer. Is of interest for other red wares than brick. The overburden and distance from rail are to be considered.

2834–2835–2836—S.½. 22-5-28w2. Near deposit of clays 2822 and 2823. Clay 2834 is practically the same clay as 2833 and needs no further comment. Clay 2835 is a nice light cream to buff burning clay of good working and drying properties, would be useful for various wares requiring stoneware clays. Clay 2836 burns to lighter shades than 2835. It has lower shrinkage and is more porous at the same cone. The two clays could well be worked as one.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	10 ft.							
2836	5 ft.	L. grey	29.0	7.0	5	3.0	10.0	L. cream
2835	10 ft.	Chocolate	33.0	8.7	5	6.8	5.0	Deep buff
Common ball concretions								
Silty Sands	5 ft.							
2834	20 ft.	Yellowish	35.0	8.0	02	3.5	10.0	Med. red
Sandstone Ledge	5 + ft.							
Overburden	12 ft.							
2837	10 ft.	Greyish	36.0	9.6	3	6.0	7.2	M. cream
Lignitic clay	? ft.							
Sandy clay Concretions	? ft.							
Overburden	30 + ft.							
2838	3 ft.		31.5	8.8	3	5.2	8.0	L. cream
Overburden	50 ft.							
Lignite	Thin							
Silts and iron concretions	25 ft.							
2841	8 ft.	Greenish	42.0	15.0	04	6.4	4.1	Med. red
2840	2 ft.	Chocolate	33.4	9.7	5	5.6	7.6	L. cream
2839	4 ft.	L. grey	33.4	10.0	1	6.7	5.4	M. cream
Lignitic shale	6 ft.							
Coal seam worked in the past	? ft.							
Overburden								
Silts								
Shale	? ft.							
2842	10 ft.	Yellowish and grey	38.6	10.6	04	8.6	2.4	Med. red
Coal Seam								

2837—S.W. 22-5-28w2. Another outcrop on same section as 2822 and 2823. Clay 2837 is a stoneware clay of good properties other than its total shrinkage is a little high. It starts to bluestone at cone 5, and its absorption drops to 4.7 per cent. This is a useful clay for several wares.

2838—S. 15-5-28w2. Near the home of some Indians, and at entrance of a small coal mine. Clay 2838 is also a stoneware clay of good working properties though the total shrinkage should be reduced. At cone 5 it starts to bluestone and the absorption drops to about 2 per cent. There is no doubt more of this clay than the small depth exposed and sampled.

2839–2840–2841—S.W. 23-5-28w2. Clay 2839 and 2840 are both good working stoneware types of clays. The first would be improved by a blend with the latter. Clay 2839 at cone 5 is nearly non-absorbent while clay 2840 at the same cone still has a 7.6 per cent. absorption. Clay 2841 is a clay-shale high in bentonite. Its drying shrinkage is excessive such that this clay must be ruled out as a clay, even though it burns to nice reds. It should be more useful as a bentonite.

2842—N.½. 24-5-28w2. At an abandoned wagon coal mine N.W. from Willowbunch about one and a half miles. Clay 2842 would likely give trouble in the drying of full sized ware like brick, its colour and vitrification range are both narrow. The same type of clay occurs at a less distance from rail and town.

2843—S.E. 23-5-28w2. One quarter mile S.E. from 2842. Clay 2843 is a yellow ware-stoneware type of clay a little high on absorption at cone 5. It is very much the same clay as those of 2836 and 2840, and is a useful clay.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden								
Shales								
Silts	60 ft.							
Greenish clay	7 ft.							
2843	4 ft.	Dark shale	31.0	8.9	5	3.8	9.1	L. cream
Unknown								
Coal								
Overburden	40 ft.							
Bentonitic clay	8 ft.							
2846	2 ft.	Chocolate	38.0	13.8	5	6.6	3.9	M. buff
2845	4½ ft.	Grey	34.0	9.8	3	.....	5.2	L. cream
2844	6 ft.	Chocolate	42.6	11.0	3	.....	7.6	M. cream
Coal								
Overburden	4 ft.							
Sandy concretions	1 ft.							
2848	5 ft.	D. grey	32.4	9.6	1	6.0	4.3	Cream
2847	4 ft.	Sandy	27.6	6.5	02	0.6	11.5	Med. red
Coal								
Overburden	30+ ft.							
2851	3 ft.	Chocolate	25.7	8.2	5	0.6	9.6	L. cream
2850	3 ft.	Greyish sandy	26.6	6.4	5	4.5	7.0	M. cream
2849	4 ft.	Bluish	33.1	9.3	02	5.0	6.2	Bluestone

2844–2845–2846—S.½. 14-5-28w2. S.W. up coulee from a coal mine. Clay 2844 is highly plastic and would crack during drying. It is a light burning clay which would prove useful with other clays of the stoneware type. It bluestones at cone 5. Clay 2845 is a little less plastic, its drying shrinkage should be reduced for most wares. It burns to satisfactory light shades of a slight yellowish tint. It starts to bluestone at cone 3 and attains 0 absorption at cone 5. Clay 2846 other than being a little less plastic and having slightly higher burning temperatures than clay 2844 is very much the same. At cone 5 it still has 4 per cent. absorption. These three clays could form the basis for a number of wares made from stoneware clays.

2847–2848—S.E. 14-5-28w2. S.W. of Willowbunch, near Indian shacks. Clay 2847 is a sandy shale of low plasticity and total shrinkage. Its burned shades are satisfactory for common brick, its absorption is not overly high for soft mud common brick. Clay 2848 is a light burning clay which burns to good cream shades with bluestoning starting at cone 1 which is low. This clay could be used with a lower shrinking and more refractory clay to good advantage.

2849–2850–2851—N.W. 12-5-28w2. Along roadway S.W. of Willowbunch. Total beds not well exposed. Clay 2849 is highly plastic and has too much drying shrinkage and would be greatly improved through a blend with clay 2851, or better a blend of all three clays at this deposit. Their general use would be for all heavy pottery, terra cotta, face brick, sewer pipe and other like wares, though to no better purpose than clays from many other deposits in the Willowbunch area.

NOTE:—This deposit corresponds very closely to that in which 2839–2840 and 2841 occur.

NOTE:—The beds where sampled appear to have been disturbed through a small slide possibly.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	30 + ft.							
2853	2 ft.	Chocolate	38.0	13.3	5	4.0	7.6	L. cream
2852	5 ft.	Choc. and Grey	30.3	10.3	5	1.0	9.0	M. cream
Overburden shales and silts	30 ft.							
2856	3 ft.	Shale L. grey	34.6	13.0	3	6.0	1.4	Deep yellowish buff
2855	10 ft.	Chocolate	35.0	13.0	5	5.5	7.0	L. cream
2854	8 ft.	Grey	22.0	4.5	5	0.0	12.0	L. greyish cream
sandy Silts	? ft.							
Calcined glacial clay	6 ft.	Red						
Calcined shale	3 ft.	Red						
Ashes	Few ins.	White						
2857	15 ft.	Red and grey	40.0	9.2	02	4.5	4.2	Dark red
Shale	? ft.							
Lignite								
Bentonitic clay	? ft.							

2852–2853—S. 7-5-27w2. On roadway near top of hill south of Willowbunch. Clay 2852 while of good plasticity shrinks too much for use alone. It does not bluestone at cone 5. While a useful light burning clay, there are much better deposits near by. Clay 2853 burns to lighter shades than the clay just below it, and has a higher total shrinkage. Its absorption at cone 5 is a little lower. While also a useful clay there are better deposits.

2854–2855–2856—N.½. 6-5-27w2. This deposit is near the top of the hill on the road south of town, it is on the Dionne farm. Clay 2854, a small sample was taken of the lower three feet of the first beds above the light burning clays. It worked well, had low drying shrinkage and 0 burning shrinkage at cone 5. It should be further investigated for structural wares in particular. Clay 2855 is highly plastic and like other chocolate or dark clays of the area shrinks too much. Clay 2854 below it is a sandy clay and would be useful to control the shrinkage. Clay 2856 is very much like some of the kaolinized sand beds of the Whitemud. It is too sandy to use alone but has value as a diluent to the high shrinking light burning clays.

NOTE:—This is one of the more favourable deposits, it is not far distant from transportation and the town, also both plastic and sandy light burning clays are present.

2857—S. 26-4-27w2. This deposit is a short distance south of the elevators at Gye and east of Bonneau Lake. The outcrop is quite prominent. Clay 2857 is a deposit of reddish and grey shales below a burned zone of glacial clay and shale. The sample had a high per cent. of water of plasticity and was a little sticky but its shrinkage is just a little above that desired. It burns to good shades of red. General use would be for brick, structural tile, some red pottery and other lines of red ware, it takes a flash very easily at cone 1 and above. It should be carefully tested in full sized ware prior to capital investment.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	30 ft.							
2860	4 ft.	Grey and yellowish	38.6	9.4	1	9.0	5.0	Med. red
shale								
Coal	seam							
2859	10 ft.	Very dark	38.4	13.0	1	7.3	5.0	L. cream
Sandy clay	20 ft.	Grey						
2858	5 ft.	Greyish silty	22.7	3.5	5	7.3	1.6	Pinkish buff
Coal seam								
Overburden	0–40 ft.							
2864	3 ft.	Greyish	38.5	13.2	3	5.27	6.2	
Silts	1 ft.							
2863	10 ft.	Chocolate	31.0	10.2	5	2.7	10.3	L. cream
2862	3 ft.	Rusty	29.0	7.6	3	3.8	11.4	Dark red
2861	5 ft.	Grey	26.2	4.8	3	4.8	8.2	Pinkish cream
Coal	Seam							
Silts								

2858–2859–2860—S. 4-5-27w2. Clay 2858 is a silty material of little interest, it does not burn to a suitable colour for high grade wares. The only ware it might be considered for would be soft mud common brick. Clay 2859 is a clay of the light burning group, both plasticity and shrinkage are too high for use alone. Its burned shades are practically the same as clay 2855. When blended with a less plastic clay it would be of interest for those wares common to stoneware clays. Clay 2860 is a lower grade clay than 2859, it is less plastic, of good working properties, dried safely. It may be considered for building brick, though not of a very good red.

2861–2862–2863–2864—W.½. 10-5-27w2. On T. Bonneau property a quarter mile west of Bonneau lake. Clay 2861 is so near clay 2858 that it needs no further comments. Clay 2862 is a red burning clay of all good properties other than being a little on the gritty side. It worked well and dried safely. The shades of red cone 02 to 3 are good, it flashes easily at cones 1 and 3. It offers promise for face brick, some terra cotta, structural tile and other wares made from red to dark burning clays. Clay 2863 is a light burning clay of favourable properties both in the raw and while under fire, other than its not closing up to low absorptions. At the usual heats for yellow ware and some stoneware or other bodies, a less refractory clay when added might improve it. Clay 2864 is a semi-bentonitic type of clay, very fine grained, plastic and sticky. Too much shrinkage, cracks during drying. It is of doubtful value.

NOTE:—These samples were from a well exposed outcrop, a part of a semi-detached slump block from the main hill to the south. The equivalent to those sampled are at a much higher elevation where in place in the hill side.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	6 ft.							
2874	3 ft.	Light chocolate	36.2	12.9	3	5.0	4.5	D. cream bluestoning
2873	4 ft.	Dark chocolate	32.6	11.3	5	5.3	5.6	L. cream
2872	7 ft.	Grey	24.6	5.1	3	1.0	7.8	Greyish cream
2871	1½ ft.	Light chocolate	22.2	17.4	04	0.2	3.0	Weak red
2870	2 ft.	Grey	28.4	6.9	3	2.6	8.8	Greyish Buff
2869	3½ ft.	L. brown	43.6	14.6	04	6.8	5.5	Light red
2868	6 ft.	Buff-grey	38.6	10.5	1	7.4	2.7	Dark red
2867	3 ft.	Light buff-grey	52.2	15.0	04	10.7	4.4	Dark red
2866	2 ft.	Dark grey	60.7	22.0	04	8.4	0.8	Dark red
2865	2 ft.	Dark chocolate	58.0	16.3	04	12.1	2.9	Dark red
Lead grey shales	? ft.							
Overburden	50 ft.							
Silty Shale	10 ft.	Yellowish						
2877	8 ft.	Dark grey	34.2	9.8	5	9.1	2.7	D. cream specks
2876	12 ft.	White	25.1	5.1	5	1.4	13.1	Grey-white specks
2875	2 ft.	D. choc.	37.0	10.3	5	8.2	6.6	D. cream bluestoning.
Base unknown								

2865–2866–2867–2868–2869–2870–2871–2872–2873–2874—S.W. 7-6-27w2. This deposit is in a small coulee leading into Willowbunch from the south near the head of the lake and on Bonneau's land. Clay 2874 is yellow to buff burning clay with too much shrinkage, if same is reduced may be useful in several wares. Its general properties are those of the usua Willowbunch light burning clays. Clay 2873 is light burning clay of good plasticity, a little too high in drying shrinkage. It is much like clay 2855. It should be blended with the sandy clay below it, No. 2870, to reduce its shrinkage. The two clays might be of promise for sewer pipe, fire proofing, terra cotta, flue linings or for low grade refractories. Clay 2872 in a low grade kaolinized sandy Whitemud, fine grained, semi-plastic. See note above re its likely use. Clay 2871 is a low grade red burning clay of little further interest. Clay 2870 a fine grained sandy clay neither red nor light burning. In that there is very little of it, it has no other value than to blend with the red burning clays below, or 2871 above it. Clays 2869–2868–2867–2866 and 2865 are little different in the general raw and burned properties and should be considered together as a common blend. The red shales are good but shrinkage much too high for plastic made wares. Any further interest should be directed to the dry press method of manufacture.

2875–2876–2877—N.½. 5-6-27w2. One mile east of 2874. Clay 2875 in most of its properties this clay is not unlike clay 2873 other than it is a little more refractory; as indicated, the rate of absorption decreases between cones 02 and 5. Their uses are the same. Clay 2876 is a sandy clay of medium grain size, its chief use or importance would be that of a non-plastic material for clays 2875 and 2877. Clay 2877 while this clay is the same stoneware type as clay 2875 it starts to vitrify much earlier, a cone 1 burn being the equivalent of cone 5 for clay 2875. Specks appear at cone 3 and are bad at cone 5. Washing and screening would no doubt remove them.

REPORT ON PRELIMINARY CLAY SAMPLES

Collected During 1928 — Continued

Sample No.	Thick-ness	Raw Colour	Per cent.		Burned at cone	Per cent.		Burned Colour
			Water Plast'y	Dry sh'kge		Burned sh'kge	Absorp-tion	
Overburden	50 + ft.							
2879	7 ft.	Greyish sandy	36.6	10.6	5	8.0	6.4	D. cream
2878	5 ft.	Greyish clay & sandy	34.0	9.6	5	7.8	3.5	Brownish
Overburden	Variable							
2880	3 ft.	Red shale	32.0	4.6	02	11.2	3.4	Dark red
Base unknown								
Overburden	a mine							
2881	5 ft.	Yellowish shale	35.0	10.2	02	2.7	17.2	L. pink-ish red
					1	7.5	7.1	D. pink-ish red
Overburden	? ft.							
Lignite	2 ft.							
2882	8 ft.	Sandy shale	23.4	2.0	3	*0.74	22.8	
Shales & silts								

*—Expansion.

2878–2879—W.½. 12-6-28w2. This deposit is at the base of the higher grade ball clays at the Midland clay mine. Clay 2878 has good plasticity, drying shrinkage a little high. It burns too dark for use in whiteware but is of interest for sewer pipe, terra cotta, structural wares, possibly in yellow and stoneware. Clay 2879 is a more pure clay and burns to light shades up to about cone 5. It is more plastic than 2878, it shrinks more but has a higher absorption at cone 5. Its P.C.E. is cone 29. While off shade for whiteware it could be used with clay 2878 to the advantage of both clays for uses listed under that clay.

2880—N.½. 13-5-28w2. Taken from a burned shale pit 1 mile S.W. of Willowbunch, and below the C.N. Ry. dam. Clay 2880 has good working properties, low drying shrinkage, but the burning shrinkage is and would have to be reduced for other than common brick. A greater depth of the bed would be necessary.

2881—From the roof material of a caved in mine entry across the road from the above burned shale pit. Clay 2881 has a rather high degree of plasticity, too much drying shrinkage and burns at all cones to very weak poor shades of red. Only promise is for common brick.
2882—Taken in a new cut at the north side of the C.N. Ry. dam, S.W. of Willowbunch. Clay 2882 is too sandy, such that it expands rather than shrinks during burning up to and including cone 3, then shrinks rapidly. It is of little further interest.

Table of Fusion Tests on Clays in the Willowbunch Area.

2822	Below cone 26, non-refractory.
2823	Below cone 26, non-refractory.
2831	Below cone 26, non-refractory.
2835	Below cone 26, non-refractory.
2840	Below cone 26, non-refractory.
2843	Below cone 26, non-refractory.
2846	Below cone 26, non-refractory.
2850	Below cone 26, non-refractory.
2851	Below cone 26, non-refractory.
2870	Below cone 26, non-refractory.
2878	Below cone 26, non-refractory.
2828	Cone 26, semi-refractory.
2829	Cone 26, semi-refractory.
2830	Cone 26† semi-refractory.
2832	Cone 26† semi-refractory.
2852	Cone 26, semi-refractory.
2872	Cone 26, semi-refractory.
2827	Cone 27† semi-refractory.
2863	Cone 27, semi-refractory.
2836	Cone 28, No. 2 refractory.
2853	Cone 28, No. 2 refractory.
2873	Cone 28, No. 2 refractory.
2854	Cone 29, No. 2 refractory.
2855	Cone 29† No. 2 refractory.
2877	Cone 29, No. 2 refractory.
2879	Cone 29, No. 2 refractory.
2859	Cone 30† No. 2 refractory.
2876	Cone 32, No. 1 refractory.

Location and Information of Samples Collected During 1930

109 SAMPLES COLLECTED

OBJECT OF 1930 FIELD WORK:

1. To collect and test samples from two horizons of the Whitemud series, in the areas around Harptree, in the Big Muddy Valley south of Bengough, at Rockglen, and near Flintoft at the west end of Twelve Mile Lake.
2. To do further sampling in other districts in a preliminary way only.

Tests on clays from the two horizons of the Whitemuds have shown quite conclusively that there is a marked difference in the clays from the two zones. Those from the main or Lower Beds are principally ball and fire clays, while those from the upper horizon are less refractory, do not burn white, and are for the most part typical stoneware clays. Both are commercially important and the present work is further proof of the existence of a wide variety of commercially important high grade clays in Saskatchewan.

For the convenience of locating any given sample, and the district from which it was taken, the following list is given:

Samples:	3002	St. Victor
"	3003 to 3038	Harptree
"	3039 to 3064	Big Muddy
"	3065 to 3084	Rockglen
"	3085 to 30100	Flintoft
"	30101	Knollys
"	30102 to 30103	Fir Mountain
"	30104 to 30109	Roche Percee

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
3002			Dark red Cone 02	Dark red	Overfired	N.E. 5-4-29w2. ½mi. S. of St. Victor.
3003	17 ft.	87 ft.	Pink cone 02	Greyish	Overfired	N.E. 5-4-26w2. Hills S.W. of Harptree Samples 3003 to 3014 inclusive were taken from the same outcrop in ascending order.
3004	8–9 ft.	76½ ft.	Buff cone 02	Light buff	Grey	
3005	7 ft.	69½ ft.	Buff cone 02	Buff	Grey	
3006	3½ ft.	66 ft.	Pink buff cone 02	Light buff	Reddish buff	
3007	7½ ft.	58½ ft.	Pink buff	Dark buff	Overfired	
3008	20 ft.	38½ ft.	Salmon	Light buff	Overfired	
3009	3 ft.	35½ ft.	Buff	Cream	Grey buff	
3010	4 ft.	31½ ft.	Light pinkish red	Brownish	Overfired	
3011	4 ft.	27½ ft.	Light pink cone 02	Light Pink	Overfired	
3012	3 ft.	24½ ft.	Light Pink Buff cone 02	Light Grey Buff	Green, Overfired	
3013	6 ft.	18½ ft.	Pink buff cone 02	Pink buff	Green, overfired	
3014	9½ ft.	9 ft.	Light red	Overfired	Overfired	
3015	10 ft.	16 ft.	Light red	Grey brown	Overfired	N.W. 8-4-26w2. From butte in flats S.W. of Harptree. Taken in ascending order.
3016	3 ft.	12¾ ft.	Light red	Grey brown	Overfired	
3017	7½ ft.	5½ ft.	Med. red	Bloated cone 02	Fused	
3018	4 ft.	32 ft.	Light cream	Dark cream	Bluestoned cones 4 & 6	N.E. 5-4-26w2. ¾ mi. southeasterly of previous samples, on north side of same coulee. Poor rail facilities.
3019	5 ft.	27 ft.	Light cream cone 02	Light cream	Dark bluestone	
3020	7 ft.	20 ft.	Dark buff	Bluestoned	Bluestoned	

3002—Ravenscrag shale. High absorption at cone 02, probably could be used in brick manufacture.

3003—Ravenscrag silt and shale of little use to any industry.

3004—P.C.E. 29+, of possible use in low grade refractory products.

3005—Willowbunch. Similar to sample 3004 throughout. Sandy shale.

3006—Willowbunch shale. Low burning shrinkage. Colours good for face brick at higher cones.

3007—Willowbunch light buff shale. Of little ceramic value.

3008—Similar to above sample.

3009—Top of Willowbunch clays. Black and plastic. High absorption, possibly usable as a bonding clay.

3010—Silty Ravenscrag shale. Little value.

3011—Ravenscrag silt. No value.

3012—Ravenscrag silt, similar to sample 3011, also useless.

3013—Short, poor colours, relatively useless.

3014—Ravenscrag shale. Plastic, sticky, poor colours. Not a good clay.

3015—Doubtful value, due to plasticity and high drying shrinkage. Bentonitic Ravenscrag shale.

3016—Similar to previous sample.

3017—Poorer than previous two.

3018—Black, plastic Willowbunch. High shrinkage, but useful as bond clay of stoneware type.

3019—Light grey, medium hard. Fair stoneware type clay, though would need blending. No specks.

3020—Low absorption, high drying shrinkage. Useful as blend with 3019.

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
3021	6 ft.		Salmon	Black	Fused Cone 4	N.E. 5-4-26w2. Close to, but east of previous samples.
3022	Thin seam	Heavy	Light cream	Bluestoned	Dark bluestoning cone 4	considerably below previous sample.
3023	7 ft.		Light cream cone 02	Light cream	Dark bluestoning	S.E. 5-4-26w2. West side of main coulee leading to coal mine.
3024	5 ft. (above 3023)		Light buff	Red buff	Overfired Cone 4	
3025	19 ft.		Light cream cone 02	Light cream	Dark grey	S.W. 5-4-26w2. Taken from a butte.
3026	2½ ft.		Grey brown cone 02	Grey brown	Grey brown	
3027	8 ft.	110 ft.	Salmon	Med. red	Black O.F.–Cone 4	N.W. 33-3-26w2. 1¼ mi. S.E. of above samples 3025, 3026.
3028	5 ft.	105 ft.	Light cream cone 02	Light cream	Grey	
3029	5 ft.	100 ft.	Cream	Bluestoned	Fused	
3030	4½ ft.	110 ft.	Dark cream	Bluestoned	Bluestoned cone 6	N.E. 33-3-26w2. ½ mi. east of above samples 3027, 3028, 3029.
3031	10 ft.	100 ft.	Light cream Cone 02	Light cream	Bluestoned	
3032	4½ ft.	110 ft.	Light Buff	Dark Buff	Bluestoned	
3033	4 ft.		Light cream cone 2	Light cream	Grey	S.E. 33-3-26w2. ½ mi. S.E. of previous group of samples, in same coulee. Samples taken in ascending order.
3034	8 ft.		Light cream cone 02	Light cream	Grey	
3035	1 ft.		Chalky white	Chalky white	Light cream	
3036	1½ ft.		Chalky white	Chalky white	Cream	
3037	5 ft.		Light red	Black	Fused cone 4	
3038	3 ft.		Cream	Bluestoned	Blistered cone 4	

3021—Ravenscrag, plastic shale. Poor even for brick.
3022—Useful range of colours, very low temperature, stoneware type. Would require blending.
3023—Dark plastic Willowbunch. Useful stoneware clay if blended with less plastic clay.
3024—Willowbunch, similar but quite inferior to sample 3023 above.
3025—Plastic cross-bedded Willowbunch. Excellent shrinkage, absorption, colour working properties for face brick, sewer pipe, etc.
3026—Calcareous clay-sandstone, Ravenscrag, little or no value.
3027—Working properties reasonably satisfactory but colours poor for brick. Ravenscrag.
3028—Willowbunch. Similar in quality and uses to sample 3025.
3029—Slightly inferior to sample 3028 but could be blended with it for face brick, sewerpipe, etc.
3030—Plastic Willowbunch. Free from specks, probably good bonding clay of plastic stoneware type.
3031—Willowbunch, sandier than above. Good type of facebrick and stoneware clay.
3032—Same as 3030, taken from opposite side of coulee.
3033—Sl. sandy Willowbunch. Good for stiff-mud face brick, sewerpipe, etc.
3034—Slightly inferior to above sample 3033, but could be blended with it.
3035—No. 2 refractory of fairly good properties. Too narrow for development.
3036—Similar to 3035, but slightly less refractory.
3037—Geology dubious. Little value.
3038—Plastic Willowbunch. Poor working qualities.

TABLES AND BRIEF NOTES ON THE 1930 SAMPLES — Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
3039	12 ft.	Excessive	Chalky white	Chalky white	Chalky white	N.½. 35-3-24w2. ½ mi. east of main trail.
3040	9 ft.		Light cream cone 04	Light cream	Dark cream	
3041	3 ft.		Light cream cone 02	Light cream	Light cream	
3042	7 ft.		Chalky white cone 02	Chalky white	Light cream	
3043	5 ft.	Excessive	Pink	Brownish	Grey, overfired, cone 6	S.E. 35-3-24w2. 1 mi. east of main trail, on north of valley.
3044	1¾ ft.		Light cream cone 02	Light cream	Dark grey	
3045	4 ft.		Cream, cone 04	Cream	Dark grey	
3046	10 ft.		Light grey, cone 02	Light grey	Med. grey	S.W. 36-3-24w2. Taken from butte near above samples
3047		above 3046	Reddish buff	Fused cone 04		
3048	4 ft.	17 ft.	Light cream cone 02	Light cream	Greyish	S.E. 36-3-24w2. From apparent slump block a little east of previous samples. Taken in ascending order.
3049	4 ft.	13 ft.	Light grey cone 02	Light grey	Med. grey	
3050	3 ft.	10 ft.	Light grey cone 02	Light grey	Dark grey	
3051	4 ft.	6 ft.	Light grey cone 02	Light grey	Dark grey	
3052	3 ft.	3 ft.	Light grey cone 02	Light grey	Med. grey	
3053	8 ft.	Excessive	White	White	White	N.½. 34-3-24w2.

3039—Whitemud kaolinized sand. Low grade due to contamination with various salts.

3040—Whitemud stoneware. With addition of 3039, would make good facebrick.

3041—Shale, low-grade refractory. Good additive clay.

3042—Plastic, P.C.E. cone 30, some specking. Good additive to less refractory clays.

3043—Plastic Whitemud. Possible use in dry-pressed wares.

3044—Sandy Whitemud, poor vitrification range. Useful as additive only.

3045—Chocolate, plastic Whitemud. High refractory value stoneware.

3046—Plastic Whitemud. Poor drying characteristics, P.C.E. cone 31, possible bonding clay.

3047—Battle? Little value.

3048—Whitemud stoneware similar to 3040, but with P.C.E. cone 28+ useful for firebrick and refractories.

3049—Plastic Whitemud. Possible bonding clay.

3050—Fine grained, plastic, similar to 3046, 3049.

3051—Similar to 3046, has P.C.E. of cone 30.

3052—Good working properties, P.C.E. of cone 30, good refractory clay for wide range of products.

3053—Whitemud kaolinized sand. Low grade due to salts.

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
3054	6 ft.	Excessive	Chalky white	Chalky white	Creamy white	N.W. 34-3-24w2. North side of valley about 1 mi. west of main trail, across from white butte.
3055	4 ft.		White	White	Creamy white	
3056	2 ft.		Chalky white	Chalky white	Light cream	
3057	4½ ft.		Light grey	Light grey	Cream	
3058	13½ ft.		Light grey	Light grey	Creamy	N.E. 21-3-24w2. Butte 2 mi. west of Roberts' ranch buildings.
3059			Light red	Dark red	Brown, O. F. cone 4	S.E. 18-3-24w2.
3060	7 ft.		Light red	Dark red	Greenish O.F. cone 4	S.E. 21-3-23w2. Upper Willowbunch beds 4 mi. southeast from where Highway 34 crosses valley at Roberts' ranch.
3061	6 ft.		Cream	Cream	Grey	
3062			Light buff	Light buff	Bluestoned cone 6	
3063	5 ft.		Cream	Light buff	Bluestoned cone 6	
3064			Salmon	Salmon	Tan	
3065			Light cream	Med. buff	Bluestoned, cone 6	S.E. 22-2-30w2. Dippong's farm.
3066	4 + ft.		Light cream	Grey buff	Bluestoned, cone 6	N.W. 28-2-30w2. Yost's farm.
3067	3 ft.	Excessive	Light cream cone 02	Light cream	Dark grey	S.W. 33-2-30w2. Out crop near slaughter-house, south of town. Samples taken in ascending order.
3068	4½ ft.		Pink buff	Very dark	Glossy, cone 4	
3069	4½ ft.		Light buff	Brown red		
3070	4 ft.		Light buff	Brown red		
3071	10 ft.		Light buff	Brownish		

3054—Plastic Whitemud, P.C.E. cone 30 +. firebrick or sagger clay.
3055—Whitemud ball clay. P.C.E. cone 32 + some specking.
3056—Similar to 3055 above, with P.C.E. ½ cone higher, and no specks.
3057—Speckled ball clay, P.C.E. of cone 31. Useful as bond clay.
3058—Plastic Whitemud. No. 2 refractory with P.C.E. cone 31, large specks, fair working characteristics.
3059—Bentonitic Ravenscrag. Little value.
3060—Ravenscrag shale. Doubtful value.
3061—Sandy Willowbunch, poor vitrification range.
3062—Good Willowbunch stoneware clay.
3063—Similar to and better than 3062 above.
3064—Good colours at high cones only. Doubtful value.
3065—Fair Willowbunch stoneware clay.
3066—Fair Willowbunch stoneware clay.
3067—Probably top of Whitemuds. Not quite a ball clay, could be used as refractory bond clay.
3068—Shaley Ravenscrag. No value.
3069—Shaley Ravenscrag. Little value.
3070—Plastic Ravenscrag. Little value.
3071—Ravenscrag shale. Little value.

TABLES AND BRIEF NOTES ON THE 1930 SAMPLES — Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
3072	4½ ft.		Light buff	Brown red	Glossy, cone 6	29-2-29w2. High in valley hills about 4 mi. S.E. of town.
3073	10 ft.		Light buff	Brownish	Glossy	
3074			Cream	Bluestoned	Bluestoned, cone 6	
3075	2 ft.		Light buff	Dark slate		
3076	2½ ft.		Light	Light buff	Bluestoned, cone 6	N.W. 9-3-30w2. Railway cut just E of 3rd Meridian.
3077			Chalky white	Chalky white	Chalky white	S.½. 13-3-1w3. ¼ mi. S. of railway.
3078	5 ft.	Light	Cream	Grey buff	Bluestoned, cone 4	E.½. 10-3-30w2. Butte E of railway Y
3079	3 ft.	50 ft.	Light buff	Dark grey		E.½. 10-3-30w2. ¼ mi. south of 3078 above, but at lower level
3080	6 ft.	44 ft.	Light buff	Roan	Glossy cone 4	
3081	2 ft.	42 ft.	Chalky	Pink grey	Dark grey cone 6	
3082	1 ft.	41 ft.	Poor buff	Roan	O.F. Cone 4	
3083	11 ft.	30 ft.	Light buff	Brownish		
3084			Light buff	Brownish		S.E. 33-2-30w2. Taken from Hanel well.
3085	5 ft.		Chalky	Chalky	Chalky Buff	S.W. 16-5-3w3. Road allowance near rly.
3086	6 ft.		Chalky white	Light cream	Light greyish cone 6	S.W. 16-5-3w3. Railway cut downstream from 3085 above.
3087	2½ ft.	25+ ft.	Light buff	Roan buff	Bluestoned cone 6	S.½. 16-5-3w3. In field north of track, west of sample 3086.
3088	3 ft.	22+ ft.	Light cream	O.F. Greenish buff		
3089	8 ft.	4+ ft.	Poor buff	Bloated, grey cone 04		

3072—Willowbunch shale. Little value.
3073—Probably Ravenscrag. Poor to useless characteristics.
3074—Plastic Willowbunch. Fair stoneware clay.
3075—Ravenscrag. Possible common brick clay, but doubtful.
3076—Purple plastic Whitemud, beds disturbed. Good stoneware clay.
3077—Sandy plastic Willowbunch. Low refractory P.C.E. cone 20-23.
3078—Good yellow ware clay.
3079—Willowbunch shale of very doubtful value.
3080—Sandier but similar to 3079 above.
3081—Plastic, might be used as plastic additive to other clays.
3082—Common brick clay.
3083—Yellow-green shale, only good for common brick.
3084—Ravenscrag shale suitable for low grade wares.
3085—No. 2 refractory Whitemud, suitable for face brick, saggers etc.
3086—Speck-free No. 3 refractory Whitemud. Good for face brick.
3087—Plastic purple Whitemud, No. 3 refractory, poor colours, high shrinkage.
3088—Dark plastic Whitemud. Possible Haydite material.
3089—Brownish shaley clay. Bloats easily at low temperatures.

S'ple No.	Approximate		Colour when Burned at			Location
	Thick-ness	Over-burden	Cone 06	Cone 2	Cone 8	
3090				Chalky white	Chalky white	N.E. 27-5-3w3.
3091	2 ft.	30 ft.		Chalky white	Light grey	N.W. 34-5-3w3. Taken in ascending order from a west-facing outcrop.
3092	6 ft.	24 ft.		Chalky white	Light grey	
3093	4 ft.	19 ft.		Chalky white	Greyish white	
3094	1 ft.	18 ft.		Chalky white	Greyish white	
3095	3 ft.	15 ft.		White	White	
3096	2 ft.	13 ft.		White	Creamy white	
3097	2 ft.	20–30 ft.		Light cream	Greyish	S.E. 34-5-5w3. Near S.W. corner of section.
3098	10 ft.		Salmon red	Med. red	Dark red, cone 2	S.E. 34-5-5w3. Taken above sample 3097.
3099	10 ft.			Pink	Buff	N.E. 34-5-3w3. Between 2 previous outcrops.
30100			Dark buff	Med. red	Dark red	
30101	4 ft.	Heavy		Yellow buff	Grey buff	S.E. 17-6-22w3. Above No. 14 clay in Knollys pit.
30102				Light grey	Light grey	N½. 17-5-4w3. 4 mi. west of Wood Mountain at highway at south of railway.
30103				Chalky white	Med. grey	
30104	4 ft.		Light red	Dark red	O.F. Black cone 4	Roadway cut on S. side of railway west of bridge at Roche Percee.
30105				Roan	O.F. Dark grey	

3090—Whitemud No. 2 refractory. Sandy.

3091—Plastic chocolate Whitemud. Useful as refractory bond clay. P.C.E. cone 28.

3092—Grey plastic Whitemud. Burns free of specks, P.C.E. cone 29. Useful as blending refractory.

3093—Same as 3092 above, but separated by 1 ft. lignite seam.

3094—Chocolate plastic, P.C.E. cone 30, with specks. Limited use.

3095—Chocolate to purple ball clay. P.C.E. cone 31. Specks at cone 10. Further testing required.

3096—Shaley ball clay, fairly low grade due to specks. P.C.E. cone 31.

3097—White sandy Whitemud, low shrinkage, P.C.E. cone 29, useful for blending with more plastic clay.

3098—Yellowish Ravenscrag shale. Poor drying and burning properties.

3099—Iron stained Whitemud, pleasing colours for face brick.

30100—Yellow ochry Ravenscrag. Poor drying and burning properties.

30101—Chocolate shaley Whitemud. High drying shrinkage, otherwise good for structural wares.

30102—Dark chocolate Whitemud. Considerable iron specking, good face brick material.

30103—Too much iron specking to class as ball clay, otherwise has good properties.

30104—Greenish-grey Ravenscrag. Poor burning qualities.

30105—Sandy Ravenscrag. Little use.

TABLES AND BRIEF NOTES ON THE 1930 SAMPLES — Continued

S'ple No.	Approximate		Colour when Burned at			Location
	Thickness	Overburden	Cone 06	Cone 2	Cone 8	
30106		Heavy		Pink	O.F. Greenish cone 6	Short distance upstream from Roche Percee Bridge on Souris River.
30107	1½ ft.		Light red	Very poor	O.F. cone 4	
30108	2½ ft.		Light red	Brown red	O.F. cone 4	
30109	2½ ft.		Light red	Brown red	O.F. cone 4	

30106—Grey sandy Ravenscrag shale. No value.

30107—Light to chocolate Ravenscrag shale. Little value.

30108—Plastic dark grey Ravenscrag. Possible common brick clay.

30109—Blue grey plastic. Possible use in common brick and tile.

Sample No.	% Water of Plasticity	% Drying Shrinkage Lin.	At Cone 2 % Burning Shrinkage Lin.	At Cone 2 % Absorption.	Remarks
3002	44.4	5.3	10.4	0.3	Steel hard
3003	22.7	4.5	1.6	13.7	Medium hard
3004	15.3	0.8	0.3	12.0	Medium hard
3005	17.8	3.4	0.2	12.5	Medium hard
3006	22.0	6.4	0.6	12.2	Steel hard
3007	30.5	5.4	6.6	15.0	Steel hard
3008	28.6	7.0	7.4	7.1	Steel hard
3009	30.0	11.4	2.1	7.3	Steel hard
3010	19.5	6.4	12.8	0.0	Steel hard
3011	21.3	1.7	0.7	20.3	Hard
3012	27.0	4.9	4.9	13.3	Steel hard
3013	22.0	1.7	0.1	26.9	Medium hard
3014	30.6	10.4	.....	1.1	Steel hard
3015	37.4	9.6	0.5	8.2	Hard
3016	20.9	14.2	0.1	5.9	Steel hard
3017	40.0	15.4	.....	.....	Bloated
3018	38.0	14.2	9.5	0.2	Steel hard
3019	26.3	7.7	1.5	11.3	Steel hard
3020	34.8	14.0	4.3	0.1	Steel hard
3021	32.7	7.6	12.6	0.2	Steel hard
3022	39.2	12.8	9.4	1.1	Steel hard
3023	36.3	12.7	8.0	6.3	Steel hard
3024	39.4	13.2	9.1	1.4	Steel hard
3025	26.1	8.3	1.4	11.9	Steel hard
3026	19.5	2.0	6.1	Exp.58.6	Soft
3027	28.3	9.4	6.0	2.9	Steel hard
3028	21.8	5.3	0.8	10.6	Hard
3029	25.7	7.4	5.9	3.3	Steel hard
3030	35.8	11.6	7.9	2.1	Steel hard
3031	34.6	7.7	2.6	5.8	Steel hard
3032	.....	.....	.....	.....	Steel hard
3033	26.1	7.3	2.5	10.8	Steel hard
3034	34.8	7.9	2.4	12.0	Steel hard
3035	30.5	6.1	0.4	14.6	Hard
3036	21.5	6.5	0.9	13.1	Steel hard
3037	33.0	11.5	8.1	0.0	Steel hard
3038	39.4	17.7	5.9	1.0	Steel hard
3039	24.5	5.6	1.2	15.5	Medium hard
3040	33.8	10.7	5.0	10.0	Steel hard
3041	30.0	8.0	3.8	17.3	Hard

TABLES AND BRIEF NOTES ON THE 1930 SAMPLES—Continued

Sample No.	% Water of Plasticity	% Drying Shrinkage Lin.	At Cone 2 % Burning Shrinkage Lin.	At Cone 2 % Absorption.	Remarks
3042	32.2	9.6	7.3	11.2	Steel hard
3043	42.2	14.4	7.7	0.4	Steel hard
3044	26.5	6.0	2.7	10.4	Hard
3045	33.5	8.8	4.2	15.6	Hard
3046	47.4	18.9	8.6	4.5	Steel hard
3047	54.5	21.2	.....	.....	Bloated
3048	27.8	8.7	4.7	10.0	Steel hard
3049	45.0	16.3	10.9	2.1	Steel hard
3050	46.0	17.0	9.3	3.4	Steel hard
3051	48.5	18.5	10.9	5.2	Steel hard
3052	41.2	13.0	7.4	12.2	Steel hard
3053	21.5	4.6	0.5	14.2	Steel hard
3054	32.9	7.9	5.3	17.5	Hard
3055	31.1	8.9	7.2	11.3	Steel hard
3056	34.0	10.0	7.6	11.0	Steel hard
3057	33.9	9.3	9.2	12.7	Steel hard
3058	34.3	10.1	6.7	11.7	Steel hard
3059	37.9	13.5	5.5	1.4	Steel hard
3060	43.5	12.6	10.5	0.3	Steel hard
3061	24.2	5.4	0.5	15.2	Hard
3062	35.5	10.9	6.5	7.3	Steel hard
3063	28.8	7.2	6.9	5.5	Steel hard
3064	24.9	7.3	1.5	12.3	Steel hard
3065	31.5	9.5	5.8	4.7	Steel hard
3066	36.0	11.5	8.6	0.2	Steel hard
3067	35.6	12.2	8.2	5.9	Steel hard
3068	39.4	11.8	11.0	0.2	Steel hard
3069	36.7	10.3	12.3	0.0	Steel hard
3070	35.4	9.3	13.3	0.0	Steel hard
3071	34.8	9.9	9.4	0.0	Steel hard
3072	39.3	12.7	9.8	0.0	Steel hard
3073	43.0	14.0	10.9	0.0	Steel hard
3074	35.3	11.5	8.7	0.3	Steel hard
3075	38.0	10.7	12.5	0.0	Steel hard
3076	30.7	8.2	3.0	11.8	Steel hard
3077	21.0	5.4	0.0	12.5	Steel hard
3078	32.8	9.4	7.7	3.0	Steel hard
3079	34.9	9.5	10.4	0.6	Steel hard
3080	27.8	5.8	6.3	7.1	Steel hard
3081	36.5	12.5	9.7	2.4	Steel hard
3082	35.0	10.9	7.2	4.7	Steel hard
3083	38.0	12.0	8.8	0.0	Steel hard
3084	36.3	7.4	18.9	0.0	Steel hard
3085	27.3	8.7	4.3	8.8	Steel hard
3086	27.0	8.6	2.2	9.6	Steel hard
3088	43.0	15.1	7.1	3.0	Steel hard
3089	43.9	17.2	.....	.....	Bloated
3090	49.0	21.4	0.3	15.7	Hard
3091	28.1	5.0	6.4	16.3	Steel hard
3092	39.2	10.9	3.9	16.0	Steel hard
3093	35.3	9.8	4.4	14.0	Steel hard
3094	35.3	8.7	5.9	18.7	Very hard
3095	30.5	8.1	5.2	14.6	Steel hard
3096	32.0	9.7	5.6	11.6	Steel hard
3097	29.0	7.7	2.6	14.5	Steel hard
3098	42.8	13.7	8.0	3.1	Steel hard
3099	32.1	9.6	6.6	11.1	Steel hard
30100	43.7	15.0	9.0	1.2	Steel hard
30101	40.2	15.5	1.4	9.9	Medium hard
30102	32.5	9.9	7.0	10.7	Steel hard
30103	35.5	12.6	8.9	8.3	Steel hard
30104	24.4	4.2	8.9	0.3	Steel hard
30105	19.7	1.4	0.0	15.5	Soft
30106	23.0	4.6	0.2	17.6	Soft
30107	34.9	10.2	11.1	0.6	Steel hard
30108	34.1	11.9	6.0	0.0	Steel hard
30109	30.2	8.8	8.6	0.0	Steel hard
30110	31.6	8.7	6.3	8.9	Steel hard
30111	17.6	3.3	0.0	12.7	Steel hard

LOCATION AND INFORMATION RE CLAY SAMPLES COLLECTED DURING 1931

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	10+ ft.							
3109	3 ft.	Grey	35.8	12.6	2	5.5	4.4	M. grey
					6	6.5	0.0	Blue-stoned
3108	2 ft.	D. grey	37.6	12.5	2	7.7	1.6	M. grey
					4	8.5	0.0	Blue-stoned
3107	15 in.	White sandy	24.4	6.0	10	1.7	13.0	L. grey
3106	3 ft.	L. grey	32.4	11.8	10	4.9	2.2	D. grey
Dark Shales	? ft.							
Overburden								
Shales								
Silts	30+ ft.							
3111	5 ft.	Rusty	36.0	9.0	2	7.3	14.5	M. cream
					10	11.3	2.6	Blue-stoned specks
3110	2½ ft.	Grey	34.6	8.2	02	4.2	20.3	L. cream
					10	13.0	3.6	L. grey clear
3112	5 ft.	Black to chocolate	37.5	8.8	4	6.7	16.6	L. cream
					10	6.9	14.8	M. cream specks
Earthy lignite shale	Thin							

NOTE:—In each case the reported burned properties are those at the cone where the sample is at its best average firing temperature.

3106–3107–3108–3109—S. 13-14-11w3. Deposit is part of a fault block in the general area seven miles S.W. of Neidpath. Clay 3106 is of good plasticity, but has too much drying shrinkage. Its burning properties are very good. Becomes steel hard at cone 2, but absorption of 12% at that cone is too high. For uses see notes following sample 3109. Clay 3107 is a thin seam of siliceous clay of fair plasticity and dried safely. It is quite refractory with 13% absorption at cone 10. Not enough of it to be used alone. Clay 3108 is of high plasticity and dangerous drying shrinkage. It is steel hard at cone 010 and bluestones at cone 4. It burns below that to light shade. See notes following clay 3109. Clay 3109 is the uppermost clay of this deposit, it is plastic and sticky, has high drying shrinkage, burning properties good, is steel hard at cone 02, and burns to light shades. The clays in this deposit as a whole are yellow ware—stoneware types. For the most part the beds are thin. For this and other reasons they should, if ever used, be blended as a common mixture of interest for heavy pottery, sewer pipe, all structural wares, etc. However, proof of quantity must be given first consideration.

3110–3111–3112—About one quarter mile west of the above deposit and on the same section. Clay 3110 is fine grained, plastic, likely to crack in drying, becomes steel hard at cone 02, burns to light shades and is quite free of specks. It is a ball clay and would prove useful as such. Clay 3111 is just above clay 3110 and is a lower grade clay in that it burns to darker shades, becomes very specky, it hardens early and starts to bluestone at cone 4. Might be of interest for sewer pipe, face brick and other crude wares by mixing with a more siliceous clay. Clay 3112 is just below 3110, it is plastic, total shrinkage too high, burns to fairly light shades, is specky with iron spots. It is more refractory than either of the other clays in the same deposit. Its interest would be as a blend with the other clays and for possible refractory uses.

NOTE:—These clays are of the Whitemud formation.

LOCATION AND INFORMATION RE CLAY SAMPLES COLLECTED DURING 1931
— Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	0+ ft.							
3113	15 ft.	White sandy						
3114	2 ft.	White plastic						
	10+ ft.	White sandy						
Overburden glacial	Light							
3117	? ft.	L. grey	29.0	7.4	10	11.2	4.5	L. cream
Lignitic	.....	Seam						
3116	2 ft.	D. grey	28.0	6.8	10	9.3	7.2	L. cream
3115	4 ft.	L. grey	27.2	6.7	10	11.0	4.9	L. cream
Overburden	10+ ft.							
3118	8 ft.	Grey shaley	34.2	9.9	2	6.9	9.8	
					4	10.5	0.1	
Overburden glacial shales	20+ ft.							
3119	6+ ft.	Grey-white sandy			4	4.8	9.2	L. cream
					10	5.0	7.5	L. grey

NOTE:—There are a number of outcrops in this general area. A search of same failed to locate sufficient plastic Whitemud clays to prove of interest, though there are more favourably located beds of the same clays farther south in the province. Preliminary samples only were tested.

3113–3114—S.E. 16-20-6w3. and N.E. of same section. The A. Bonds quarter west of Aquadell.

NOTE:—Clays 3115–3116 and 3117 are beds which have been badly disturbed, they are nearly vertical and may not be in place. There is little doubt re their being members of the Whitemud.

3115–3116–3117—S.E. 18-5-12w2. These clays are in the Souris Valley east of Goodwater and a little south of mile 106 on the Radville branch of the C.N. Rly.
All of the ball clay type though a little less plastic than the same types of clay near Willows. Their burned shades up to cone 10 are good. They should be further investigated as to quantity and to determine if they are in place.

3118—Taken at a railway cut bank, the first one on south side of the right of way west of mile 107. Clay 3118, there appears to be some slumping of the beds at this deposit, the angle is low. While light burning, this clay may be a member of the Willowbunch clays and not of the Whitemud. It is less refractory and bluestones at cone 4. Can be considered a stoneware clay.

NOTE:—This deposit was more fully investigated in 1946 and 1947, see report of those years for greater detail.

3119—N.W. 13-5-13w2. This deposit is at the C.N. trestle over Jewel Creek about three miles east of Goodwater. Clay 3119 is of fair plasticity though sandy, dries safely, becomes steel hard at cone 4, colour good though many specks at higher heats. This deposit should be more fully prospected in that it offers possibilities of being beds of the Whitemuds in place.

NOTE:—The return to Carlyle Coulee was to collect large samples of clays 2747–2748–2749 and 2750 for final testing.

LOCATION AND INFORMATION RE CLAY SAMPLES COLLECTED DURING 1931
— Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden shales silts 3120	Excessive 6 ft.	L. grey silty	28.8	9.6	07	2.0	11.2	Chalky white
					10	5.0	7.5	L. grey
Overburden shale silts lignite 3122	100+ ft. 3 ft.	D. grey	32.7	8.6	4	8.9	6.9	Creamy white
					10	11.4	5.8	Creamy white
3121	3 ft.	Very dark to near black	32.6	8.2	4	10.2	9.5	Creamy white
					10	11.1	8.0	Creamy white
Overburden shales lignite 3123	30 ft. Thin 5 ft.	D. grey	20.1	6.1	4	0.1	11.6	M. cream
					10	0.0	11.4	M. cream
Overburden silts sandstone 3125	15 ft. Thin 6 ft.	L. grey	29.5	8.9	02	3.3	12.9	Creamy white
					4	8.2	2.5	Grey Many specks
3124	12 ft.	L. grey	23.0	6.0	4	3.3	8.2	L. buff
					10	5.2	4.2	L. grey

3120—S. 7-1-21w2. In Carlyle Coulee, Lower Big Muddy Valley. Clay 3120 the plasticity is low, body too silty, dry shrinkage high, burned shades poor, bluestoned at cone 02 and was steel hard at cone 07, and overfired at cone 6. Only useful for low grade wares like common brick or to add to other clays.

3121–3122—N.W. 34-3-24w2. About one and one half miles west of Highway 34 where it crosses Big Muddy Valley. Clay 3121 is a ball clay, plasticity rather rubbery, shrinkage normal for this type of clay, rate of vitrification slow, burned colour good though not white. Clay 3122 other than raw colour this clay is the same as 3121 and could be worked together as a single ball clay of steel hardness, at cone 02 there are some specks. These clays are so low in the valley that they can only be recovered by mining.

3123—S.W. 8-4-26w2. In the high hills S.W. of Harptree and well up on the west bank of a coulee leading to a large spring. Clay 3123 is a gritty clay of low plasticity and total shrinkage. It dried safely, becomes steel hard at cone 02, best colour range is from cone 4 to cone 10 inclusive. Colours are weak and poor. Might offer interest as a low grade refractory.

NOTE:—These two clays are a division of sample 3025 of last year, a Willowbunch clay.
3124–3125—S.W. 5-4-26w2. At the base of a butte on the north side of a wagon trail to the south east. Clay 3124 has good working properties, the burned shades are those of yellow ware—stoneware clays and could be used for those wares if washed to remove the small iron concretions, also for sewer pipe, terra cotta, brick and other structural wares. Clay 3125 is a little finer grained and more plastic also less refractory and would be useful as an addition to clay 3124 just below it. It has many small iron grains.

LOCATION AND INFORMATION RE CLAY SAMPLES COLLECTED DURING 1931
— Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden silts shale	15 + ft.							
3126	2 ft.		35.2	9.3	07	2.1	15.2	D. cream
					4	8.4	0.1	Bluestone
Lignite	3 in.							
Overburden shales	0–30 ft.							
3130	8 ft.	yellow shale	28.5	7.8	04	0.7	25.5	L. pink buff
					2	2.3	18.7	L. cream
					4	.....	.....	Melted
3129	4 ft.	Dark to black	38.8	12.7	02	4.8	13.0	Chalky grey
					10	9.0	2.8	Bluestone
3128	3 ft.	Dark some iron	22.0	6.9	4	1.7	10.2	L. grey
					10	1.9	8.6	M. grey
3127	5 ft.	Light	31.7	10.6	07	1.2	13.8	L. cream
					6	7.9	0.8	Bluestone
3131	1½ ft.	Chocolate	.....	.....	.....	.....	.....	
Overburden	5–10 ft.							
3132	5 ft.	White	39.0	2.9	07	6.8	25.5	L. red
					02	7.8	19.5	Greyish
					2	17.8	0.0	Very dark
					4	Melted		
Overburden	5 + ft.							
3134	12 ft.	Red	29.0	8.2	07	1.9	15.2	Pink
		Yellow			02	5.5	9.2	Cream
		Pink etc.			4	9.4	0.1	Bluestone
3133	10 ft.	Greyish buff	23.2	5.3	02	0.6	16.3	L. cream
					10	4.9	7.7	L. grey

3126—N.W. 6-3-2w3. At high cut bank about one mile north of Strathallen where No. 2 Highway turns S. westward near a small bridge. Clay 3126 was very plastic, and too much drying shrinkage, worked well. Steel hard at cone 010, it is a low fire stoneware type of clay. Not enough of it to consider.

NOTE:—Other than clay 3130 the others in this deposit are all clay in the Willowbunch formation, and would prove best blended.

3127–3128–3129–3130–3131—S.W. 36-2-3w3. About one quarter mile south of Strathallen and on the Spahr quarter. Clay 3127 is nearly white when dry, and blue when damp or fresh dug. It is very plastic, fine grained, shrinks too much in drying, is steel hard at cone 07, has low fire shrinkage, good clear shades for yellow ware and stoneware. Clay 3128 is quite sandy and has low safe shrinkages. It works well. Absorption too high at cone 10, should be added to clays 3127 and 3129. Clay 3129 while the same type as 3127 is not quite as clean burning, though washing for stoneware would improve it and also if blended with 3128. Clay 3130 is a shale of little interest other than possibly for common brick, it melts rather suddenly at cone 4. It is not a member of the Willowbunch formation. Clay 3131 other than to determine thickness was of no particular interest and was not tested.

3132—N.W. 16-2-2w3. Taken at an excavation for a bank barn on Morrison quarter. Clay 3132 proved to be a sample of Marl and not a white clay. There is evidence of a large quantity of this marl.

3133–3134—S.W. 15-3-1w3. In the "Big cut" at mile 6 on the Killdeer branch of the C.P. Rly. from Rockglen. Clay 3133 is just below 3134, it is a siliceous clay and more refractory than that clay, has fair plasticity, low shrinkage, and of general stoneware colours when burned but has too high absorption at suitable heats for that class of ware. Would be improved with addition of 3134. Clay 3134 is very fine grained, of several colours like paint clays, is of good plasticity and fair total shrinkage, becomes steel hard at cone 07, of doubtful value alone but with clay 3133 might prove of interest for some heavy pottery, sewer pipe, fire proofing, face brick and other wares than refractories.

LOCATION AND INFORMATION RE CLAY SAMPLES COLLECTED DURING 1931
— Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden shale	20 ft.							
3141	3 ft.	Grey	36.1	9.7	4	11.0	5.4	L. grey
					10	11.4	2.3	L. grey Dark specks
3140	6 ft.	Rusty	34.5	9.8	02	5.9	13.9	L. grey
					6	.....	.....	Blistered
Iron concretions		Rusty						Overfired
3139	5 ft.	Greyish	30.7	8.3	4	10.4	7.5	L. cream
					10	11.0	4.5	M. grey D. specks
3138	1 ft.	Purplish	32.5	8.2	4	10.3	8.4	Grey-white
					10	10.4	6.9	Grey-white D. specks
3137	1 ft.	Chocolate	36.4	9.7	2	7.0	14.9	L. cream
					10	8.7	10.5	L. cream Specks
3136	8 ft.	Light and dark sandy	27.4	8.0	2	2.4	14.4	L. grey
					10	3.3	10.8	L. grey
3135	4 ft.	Greyish sandy	21.4	4.8	2	0.3	16.4	Buff
					10	0.6	15.4	Greyish blistered
Overburden	heavy							
3142	5+ ft.	L. grey sandy	26.4	6.4	4	3.8	14.4	Greyish white
					10	4.5	12.1	Darker specks

3135–3136–3137–3138–3139–3140–3141—S.E. 16-5-4w3. Taken at a small butte on the north side of the C.P. Rly. and about three and one half miles east of Fir Mountain Clay 3135 is a low grade greyish sand at the base of the butte. There is sufficient plasticity to work well and it dries safely. While of a refractory type it carries soluble salts which cause surface fluxing and blistering of the iron impurities and therefore would likely cause sticking of ware made from it. Clay 3136 is a light and dark zone of siliceous clays, semi-plastic, moderate shrinkage. Burns to greyish shades and has a 10% absorption at cone 10. This is a No. 2 grade refractory clay. Might be of interest for ware falling into that class. Clay 3137 which is just above the last sample, is less siliceous, finer grained, more plastic and of much higher total shrinkage. It is of No. 2 refractory value and could best be used with clay 3136. Clay 3138 is a thin seam of purplish clay also some what siliceous. It has a little higher degree of refractoriness than the two samples just discussed. It should be mixed with them. None of them are whiteware clays, all of them become steel hard at cone 02. Clay 3139 is more plastic and is of the ball clay type which burn chalky white at cone 02 and are steel hard. At cone 10 it is some darker and has developed iron specks from cone 4 up. If it can be properly cleaned, then it holds the general uses for ball clays. Clay 3140 is a low grade very dirty ball clay, so impure that it blisters very badly at cone 6 up. It might have an interest for flashed speckled face brick at about cone 2 or 3. The large iron concretions near the base of the bed must be discarded. Clay 3141 is of the same order as 3140 other than being a little less contaminated with iron, and it should be used with that clay.

NOTE:—In general the clays of the area as represented by those discussed cannot be considered very highly in view of much better clays farther east. Further work in the area as a whole is desirable.

3142—N.½. 15-5-4w3. Taken south of the railway and about three quarters of a mile east of the last samples. The outcrop faces east and there is a large butte east of it. Clay 3142 is a sandy white clay of the Whitemud, has low plasticity and shrinkage, can be molded. While it is an average No. 2 refractory it carries soluble salts and surface blistered at cone 4 up. Some dark specks from small iron grains.

LOCATION AND INFORMATION RE CLAY SAMPLES COLLECTED DURING 1931
— Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden shale glacial	15 + ft.							
3144	6 ft.	Yellowish	45.0	13.9	2	8.9	10.2	M. cream
					10	9.2	7.6	Bluestone grey specks
3143	2 ft.	D. grey purplish	39.4	13.7	2	6.8	10.3	Nearly white
					10	9.7	1.2	Grey white specks
Dark Shale?								
Cover	0 + ft.							
3145	15 + ft.	Grey and white	.....	.....	.....	.....	.....	.....
3146	Not de-termined	Olive green	.....	.....	.....	.....	.....	.....
Overburden silts glacial	5 + ft.							
3148	10 ft.	D. grey	35.2	11.7	07	0.8	15.0	L. cream
					2	4.9	7.4	L. grey
					4	6.7	1.5	Bluestone
3147	5 ft.	Black and grey	43.0	13.6	07	5.6	11.8	D. cream
					2	10.8	0.2	Bluestone
					4	.....	.....	Overfired
Rustybrown shale								

3143–3144—S.W. 13-14-11w3. At the "Big Hill" south west of Neidpath. Samples taken a little north of 3110–3112. Clay 3143 was sampled a little to the north of 3110–3111 and 3112 and under 3144. It is very much the same clay in its burned state as 3110 so that the notes for it may be applied other than there were a few more specks. Clay 3144 occurs just above 3143, it is fine grained, highly plastic, could not be used alone, the shrinkage is too high. In general it corresponds to clay 3111, see notes on that clay as well.

3145—Same location as above only across a large coulee to the north and near the top of the north wall of same. This is a sample of volcanic ash.

3146—N.W. 13-14-10w3. In a roadway cut at a diversion south of Neidpath. This is a sample of olive green bentonite. Further examination of area desirable.

3147–3148—S.W. 13-14-11w3. At the "Big Hill" S.W. of Neidpath. Samples taken a short distance N.W. of samples 3106–3109 and in the same hill and fault block. Sample 3147 is a shale like material of conchoidal fracture and rests on a rusty brown shale unsampled. This clay would crack during drying, it vitrifies much faster than clay 3109 which it is somewhat like, it is steel hard at cone 010 and bluestones at cone 2. It is a stoneware type of clay but is not all that could be desired. Clay 3148 other than burning to lighter shades and of a slower vitrification rate is very much of the same quality as clay 3147; it is however the more desirable of the two, but must be blended with a more siliceous clay.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	Light							
Lignite								
Clay	2 ft.	Dark						
3902	2 ft.	Dark and	31.8	10.7	01	2.7	14.7	White
Ball Clay		Light			2	4.4	13.5	White
					4	5.2	9.9	L. cream
					8	6.4	8.2	L. cream
					12	7.0	7.2	Very L. cream
					14	7.5	4.8	Very L. cream Quite free of specks
3901	5 ft.	Dark	35.4	10.7	01	4.1	15.7	Nearly white
Ball Clay					2	6.1	11.6	Nearly white
					4	9.2	6.1	Little darker
					8	10.1	4.9	L. cream
					12	10.7	3.7	L. greyish
					14	11.7	1.6	Overfiring Specks cone 10 up.
Iron Seam	.....	Rusty						
To Valley								
Level	10 ft.							
Overburden	10 ft.							
3903	4 ft.	Grey	42.0	11.4	01	7.5	11.1	Nearly white
Ball Clay					2	8.4	9.2	L. cream
					4	10.0	4.3	M. cream specks
					8	12.2	3.8	M. cream specks
					12	12.3	1.1	Blueston-ing.
					14	12.8	0.7	Same, specks

3901–3902—N.W. 7-8-28w2. Taken on the Conway quarter on 2nd outcrop east of the west line fence, and on the north side of the valley N.E. of Willows. Sample 3901 is a dark ball clay which shows a few iron stained spots. By very slow drying it was possible to dry the trials safely. Some of the trials are checked upon cooling. The speck forming impurities would no doubt be removed if this clay was used in a screened and magneted whiteware body. The bed is of a fair thickness. Sample 3902 is the lighter bed of clay above 3901, it is not quite so fine grained and is somewhat slower or more difficult to vitrify to the same degree, it is not overfired at cone 14. It would be a useful ball clay to use at the higher temperatures.

3903—E.½. 13-7-29w2. Taken about two and a half miles S.E. of Willows in the coulee west from No. 13 highway and north of the coal mines. The sample was from a small test pit on the south side of the valley. Sample 3903 may not be wholly representative of the deposit as a whole in that the test pit was made largely for checking purposes. The sample as taken is quite fine grained and tended to crack during drying, it vitrifies fairly regular. The burned shades are rather dark and there are many specks. Deeper under cover this clay might be cleaner. It is of interest that its volume change is very little from cone 8 on.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
3904 Ball Clay	2½+ ft.	White	38.6	8.6	01	4.0	26.4	Chalky white
					2	4.4	22.7	Same
					4	7.6	19.5	Same
					6	8.7	14.0	Same
					8	9.8	12.4	Same
					10	11.0	9.1	Same
					12	11.2	9.2	Same
					14	12.6	6.4	Same Very free of specks.
3906	.....	.....	.....	.....	.....	.....	.....	.....
3905	.....	.....	.....	.....	.....	.....	.....	.....
Overburden	Very heavy							
Lignite seam	3–4 in.							
3910 Ball Clay	2½ ft.	Greyish	31.7	9.4	01	6.6	11.3	Nearly white
					4	8.3	8.6	Same
					6	8.4	7.9	Same
					10	9.7	6.3	L. cream specks
					12	9.9	5.5	Very L. grey
					14	11.5	2.8	Same, specks
3909 Ball Clay	4 ft.	Lighter greyish	37.4	10.7	01	9.1	9.8	D. cream Very specky
					4	12.0	4.2	Same
					8	13.1	3.4	Same
					10	13.1	2.3	Greyish
					12	13.4	2.0	Greyish
					14	13.9	0.6	D. blue-stone
3908 Ball Clay	2½ ft.	Very dark & flinty	29.2	8.7	01	5.2	12.6	Nearly white
					4	8.5	5.4	L. cream
					6	8.7	6.3	L. cream
					10	9.5	4.4	L. cream
					14	11.2	1.9	Bluestone grey
3907 Clay?	1½ ft.	D. brown to chocolate	31.3	7.2	01	4.6	25.6	M. cream & specks
					2	4.2	24.5	Same
					6	4.7	24.1	Same
					10	5.2	22.4	Same
					14	7.1	19.0	Same
Hard Sandy bed	3 ft.	Brownish & plant stems						

3904—N.E. 27-5-3w3. On the Kerash quarter north of the white butte and west of the Flintoft-Wood Mountain road. Sample 3904 is from a fairly persistant seam of white plastic clay in the general district, its thickness varies considerably from place to place and it is wholly absent in some outcrops. It is fine grained and not excessively plastic, is a little rubbery when tempered. It is, as a ball clay, quite refractory and very slow in its rate of vitrification. It has been tested as a clay for use in sheet steel and iron enamels. While useful for the purpose it did not measure up to most clays in daily use for that purpose. If it occurred in greater quantity it might be of refractory interest.

NOTE:—These two numbers were missed in numbering the field samples of the season. Hence there are no clays represented by them. (3905, 3906)

3907–3908–3909–3910—E.½. 28-3-24w2. This outcrop is on the south side of Big Muddy Valley 1.6 miles west of Highway No. 34 at the old Roberts' ranch buildings. Sample 3907 is near the base of the outcrop, it is a highly carbonaceous clay of very low plasticity. The clay reacts like a jelly and was difficult to mold. Due to the high carbon content the body remained very open and highly porous even at cone 14. Its burned shades were creamy. This clay is of little interest as a ball clay. The bed is thin and mining would be necessary.

NOTE:—It is of passing interest that this bed carries small pieces or grains of resin.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1939—Continued

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	60 + ft.							
Lignite	Thin							
3913	2 ft.	Dark chocolate	36.6	9.8	01	6.7	13.3	Nearly white
					2	7.7	11.7	Same
					4	10.7	5.7	L. cream
					8	13.5	3.9	Same
					12	13.3	2.7	Same
					14	13.5	1.0	Bluestone grey
Lignite	Thin							
3912	5 – ft.	Very L. grey	35.2	10.4	01	9.4	8.7	Nearly white
Ball Clay					4	9.6	7.3	Nearly white
					8	11.0	6.3	L. cream
					10	11.2	4.6	L. cream
					14	11.9	2.5	L. blue-stone
3911	3 ft.	D. grey nodular	31.2	8.5	01	3.7	15.4	Nearly white
Ball Clay					2	7.2	11.7	L. cream
					4	8.7	7.7	L. cream
					8	10.6	7.5	L. cream
					12	10.6	6.0	L. cream
					14	12.1	2.6	Bluestone grey
Valley floor 10 ft. lower								

Sample 3908 was not very plastic, had a short tempering range and the body was rubbery. Its rate of vitrification is gradual with bluestoning taking place near cone 14. All trial pieces shattered badly during cooling. From the present data it does not appear to be very good. Sample 3909, this seam of clay carries small iron concretions. The upper half is freer of them. It is fine grained and fairly plastic, but is so contaminated with iron that it is of very little interest as a ball clay, but might be more useful as a refractory clay, but it air checked quite badly during cooling. Sample 3910 was of good plasticity and the test trial pieces dried safely. Its vitrification rate is slow and fairly continuous up to cone 14. At the lower heats it is very light and free of specks. These start to appear at cone 10. It is the one clay in this deposit of most promise as a ball clay.

3911–3912–3913—W.½. 34-3-24w2. Taken on the north side of Big Muddy Valley at a large outcrop 1.2 miles west of Highway 34 south of Bengough. Sample 3911 is only fairly good as to plasticity and is rubbery. The rate of vitrification is gradual with bluestoning at cone 14. There was much cracking during cooling. This bed of clay is a continuation of 3908 across the valley to the south. Like that sample, this one does not become very dense at cone 14. Sample 3912, this clay bed is unquestionably a more pure part of bed 3909 across the valley to the south. It remains a little too open for most ball clay uses. If it could be mined cheaply it might be of interest for refractory use, but even though remaining quite open it air shattered upon cooling. Sample 3913 is a fine grained dark chocolate coloured clay, has good plasticity. It is a ball clay like many others in Saskatchewan. It does not vitrify to a dense body as early as is desirable for most uses. Its burned shades are good and it is nearly free of specks. In cooling it shattered very badly.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	Event'ly 200 ft.							
Lignite	7 in.							
3916	3 ft.	Brownish	42.5	16.7	2	6.7	6.9	L. cream
Ball Clay					4	7.2	4.8	M. cream
					6	.....	.....	Same
					8	9.1	4.8	Same
					10	8.5	3.3	Slight greyish specks
					12	8.7	2.9	L. blue-stone glossy surface.
					14	9.2	1.1	Deeper bluestone, specks.
3915	2½ ft.	Darker grey	43.4	17.6	2	8.0	5.2	Creamy white
Ball Clay					4	8.0	2.0	L. greyish
					6	8.7	0.0	Same
					8	10.5	0.0	Same
					10	9.6	0.0	Very light bluestone grey
					12	10.0	0.0	Same
					14	9.9	0.0	Same
3914	5 ft.	L. grey	46.8	13.6	2	10.8	6.2	L. cream
Ball Clay					4	11.6	0.7	Same
					6	12.0	0.4	Same
					8	14.6	0.0	Same
					10	12.9	0.0	Bluestoning
					12	13.7	0.0	Over-firing
Sandy	3 ft.	Brown						
Sandy	2 ft.	Grey						
Sandy	.....	White						

3914–3915–3916—S.E. 36-3-22w2. Taken at the last large outcrop near the east line fence of the section, and on the west face of the exposed beds. Sample 3914 is a very fine grained clay which requires a high per cent. of water of plasticity and in consequence a high drying shrinkage. While its burning shrinkage changes very little, the absorption drops very sharply by the time cone 4 has been reached. It shattered badly upon cooling. While it is an early vitrifying clay but has a very high total shrinkage, bluestones and starts to expand or overfire at cone 10. As a ball clay small per cents of it might be used to give early strength to low fired whiteware bodies. It and all other like clays in the Big Muddy Valley can only be recovered by underground mining. Sample 3915 is practically the same clay as 3914, it is a little rubbery when tempered, has a very high shrinkage in drying but little change in same while under fire. The vitrification is very rapid between cone 2 and cone 6. It bluestones at cone 10 the same as clay 3914 below it. See notes for that clay and apply them to this clay as well. Sample 3916 is the top clay seam just below the lignite. In the raw state it is a little rubbery when tempered, has a high dry shrinkage, nearly duplicating clay 3915. While the burning shrinkages are a little lower, the rate of vitrification is much slower and more regular, it would not harden up low fire bodies as well as the two preceeding clays. Its general use, though not so free of specks would be the same as 3914.

Sample No.	Thickness	Raw Colour	Location	Remarks
				NOTE: All new 1940 samples were preliminary only and were tested for colour and general properties only.
4001 Shale	18 inches	Dark chocolate	E½28-3-24w2 Taken 1.6 miles west of highway 34 west of Roberts' ranch buildings.	This sample was taken at the base of the same outcrop where 3907 was taken last year. It occurs about three feet above a white sandy bed. It is blocky in form, sticky when plastic, burns to a clear red, has too much shrinkage. Of no further interest.
4002 Shale	2 feet	Light brown	As above.	This thin bed rests on 4001 and carries up to 3907. It is high in carbonaceous matter, and burns punky. Like 4001 below it, it is of no further interest.
3910	2½ feet	Greyish		These were all resamples in larger quantities of the same beds of last year. See report for 1939 for details of primary properties.
3909	4 feet	Little lighter		
3908	2 feet	Dark	As above.	
3907 Ball Clays	1½ feet	Dark chocolate		
3916	3 feet	Brownish	SE.36-3-22w2 On north side of valley east of Highway No. 34	These three 1939 ball clays were resampled in quantity for further detailed studies in the laboratories. See report of 1939 for essential primary properties.
3915	2½ feet	Dark grey		
3914 Ball clays	5 feet	Light grey		
3913	2 feet	Dark chocolate	W½34-3-24w2 On north side of valley 1.2 miles west of No. 34 Highway	These clays were resampled for the same purpose as were those above.
3912	5 feet	Light to White		
3911 Ball Clays	3 feet	Dark grey		
4003 Clay	3 feet	Light creamy white	S.6-7-27w2 Taken at first large outcrop north of Verwood cemetery on Highway No. 13.	This is a resample of the upper three feet of sample 4312 and old 2613. It was taken above the main iron zone, was nicely plastic but burned to light cream shade and had many dark specks at cone 5. It is very much the same clay as No. 10 and would be of the same interest.

REPORT OF SAMPLES COLLECTED DURING 1940—Continued

Sample No.	Thickness	Raw Colour	Location	Remarks
4004 Bentonitic Shale	4 feet	Dark grey	As above. Though about 250 yds. farther north and just below the heavy grey sandy bed.	This a is sample taken from the bentonitic zone and was collected for testing as a bleaching clay. It is very fine grained, has an excessive drying shrinkage and burns to a greyish-cream shade at cone 6. It is of little interest as a clay products clay. Of more interest when in the raw state.
4005 Volcanic Ash	2½ feet	Nearly white	NW.11-3-1w3. Taken at the Spagrud farm N.W. of Rockglen and from the Discovery Pit.	Taken as a sample of volcanic ash which occurs just above the bentonite and directly under the nodular ash No. 3726. All volcanic ash samples were collected for a separate report on Saskatchewan Volcanic Ash.
3726 Volcanic Ash	4½ feet	Greyish to white	As above.	This bed of ash is distinctly nodular and stands up well when exposed, it can be worked with the bed below and other ash above. Its properties are to be in the volcanic ash report.
4006 Volcanic Ash	5 feet	Whitish when dry	S½.8-3-30w2. Taken on the Ross farm at an outcrop S.W. of the buildings and on the south face of the big hill.	Taken near the top of the big hill, south west of the buildings, and on the south face. It proved to be a silty bed in the Ravenscrag and is of no further interest.
4008 Volcanic Ash	8 feet	Nearly white	S.2-6-29w2. Taken from the white outcrops which can be seen to the NE of St. Victor.	There is a bed of bentonite just above ash 4008. There are thin seams of cracked bentonite near the top of this sample.
4007 Volcanic Ash	5 feet	Yellowish		Bed 4007 at the base is of a darker shade and is somewhat better stratified. Details are in the volcanic ash report.

Sample No.	Thickness	Raw Colour	Location	Remarks
4009 Bentonite	4 feet	Olive Green	N½.33-6-30w2. South of the road 1.2 miles east of Pickthall, on the road to St. Victor. Outcrop faces north-north west	This sample is that of a highly bentonitic material, dark and badly cracked at the surface when dry, a few inches down the bed is olive-green and it is wet and sticky. Sample is for testing as a drilling mud or other purposes.
4011 Bentonitic 4010 Sandy Clay	2 feet 4 feet	Greenish Purplish	SW.1-6-1w3. At the west side of the "Sugar Loaf" about one mile west of Pickthall on the road to Maxstone.	The lower sample 4010 was taken near the grass line at the "Loaf", it is a sandy clay, purplish at the top 10" then greyish lower down where there are plant remains. Rather short as to plasticity, it burns to a greyish buff at cone 6. Would not be useful alone nor for pottery use at all. Just above this bed is that of a bentonitic clay, greenish and surface crackled where dry. Above it is a dark chocolate shale-clay. Not of much further interest.
Overburden Lignite Clay Iron zone 4012 Ball Clay Clay? Grass line	Light 6 feet 5 feet 2 feet	 Dark Greyish Chocolate	E½.22-5-3w3. At the first White-mud outcrop to the west of the road in driving from Wood Mountain to Flintoft.	This sample taken just below the iron concretion zone represents one of the major ball clay zones of the outcrop, and corresponds to the same clay on Sec. 27 about a half mile north along the road. The trials dried safely, the rate of vitrification continued fairly uniform from cone 04 to cone 9, overfiring started at cone 10. The burned shades are good being light cream and with very few specks.
3904 Ball Clay	2½ feet	Creamy white	NE.27-5-3w3.	This was taken in quantity to permit of sending samples away for tests re the use of this clay as an enameling clay. See the 1939 report for comments.
Overburden Lignite 4013 Ball Clay 3904 Ball Clay	15 feet 6 feet	 Grey	As above.	This is a sample of the first six feet above the white clay 3904. It is a ball clay, rather blocky in structure, generally dark in shade. This clay has a slow rate of vitrification up to cone 3 and increases more rapidly with a slight overfiring indicated at cone 10. The burned shades are light cream and satisfactory.

REPORT OF SAMPLES COLLECTED DURING 1940—Continued

Sample No.	Thickness	Raw Colour	Location	Remarks
Overburden	Very Shallow		S.13-14-11w3. At the "Big Hill" SW of Neidpath.	These samples are a complete cross section of the *volcanic ash* beds at the outcrop near the SE corner of the hill. Each sample is covered in the special report on volcanic ash.
4017	4 feet	Lighter		
4016	2 ft. 9 in.	Darker grey		
4015	2 feet	Greyish		
4014	6 feet	Light grey		
Overburden	10 feet		S.19-13-15w3. On Swift Current Creek N.E. from Duncairn at an abandoned volcanic ash pit.	Samples 4019-4021 and 4023 are all *volcanic ash* formerly mined and prepared as an abrasive cleanser. Samples 4018-4020 and 4022 are from thin bands or seams of clay like material of a bentonitic type. The ash samples collected for the detailed study of the Sask. volcanic ash.
4023	6 feet	Nearly white		
4022	6 inches	Rusty		
4021	14 inches	Nearly white		
4020	5 inches	Rusty		
4019	4 feet	Nearly white		
4018	1 foot	Olive Green		
Conglomerate Quartzite Pebble bed	8 feet			
Overburden	40 feet		S.17-16-12w3. About one mile west of Waldeck and on the north side of No. 1 highway and at an abandoned volcanic ash pit.	This sample taken from a former volcanic ash pit, opened nearly twenty years earlier as a source of supply of ash for the production of an abrasive cleanser. See report on volcanic ash for properties of this ash.
4024	8 feet	Greyish		
Overburden	40 feet		As above only a little south in the valley and at a higher level than 4024.	This sample is that of a highly siliceous shale-like material which at time of sampling was thought to be an upper bed of the ash which it is not, it is a siliceous shale. Has not been further examined or tested.
4025	14 feet	Buff		

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
4101 Shale	.....	Yellowish	30.3	8.6	010	0.0	11.6	Pink
					07	0.8	8.9	Salmon
					04	8.1	0.0	D. Red
					1	7.6	0.0	Chocolate Overfiring
4102 Shale	5 ft.	Yellowish	34.0	9.8	010	0.0	11.4	Pink
					07	0.7	11.5	Salmon
					04	5.9	4.0	D. salmon
					1	7.3	2.0	D. buff
					3	7.5	0.9	Grey buff
4103 Volcanic Ash	8 ft.	White	.....	.....	.....	.....	.....	.....
Overburden	10+ ft.							
4105 Ball Clay	8+ ft.	D. grey	33.4	8.8	04	5.7	13.2	Nearly white
					1	6.6	13.1	Nearly white
					3	9.4	8.7	M. cream
					5	.....	5.2	L. buff
					9	.....	4.6	Deep buff
					10	.....	3.7	Deep buff specks
Iron Nodules	.....	Rusty						
4104 Ball Clay	3 ft.	Chocolate	31.2	8.1	04	3.4	14.6	White
					1	5.5	11.9	White
					3	5.9	11.8	White
					5	7.1	7.7	L. cream
					9	.....	7.2	L. cream
					10	7.9	7.2	L. cream specks
Clay	1 ft.	Blackish						
Sandy	2½ ft.	White						
Sandy	3½ ft.	Chocolate						
Sandy fine	3 ft.	Dark						
Sandy coarse	1 ft.	Light						

4101–4102—S. 23-6-2w3. At the new and old mines of Paul Tereta south of Stonehenge. Sample 4101, from the new mine. Sample 4102 from the old mine. Sample 4101 was a soft shale. The sample was taken from a "cave in" of the roof in the Tereta coal mine south of Stonehenge. About 6 ft. was sampled. This clay was plastic, did not crack while drying in the small pieces. When burned it is safe up to and including cone 07, it then fails very rapidly and has too much shrinkage. It might prove useful for common brick. Sample 4102 was taken from a parting seam in the old mine. It is more plastic than 4101, and has a higher drying shrinkage. It is a better clay for burning to lower absorptions than 4101 but it vitrifies too rapidly from cone 07 to cone 04. Its chief interest would be to test for common brick.

4103—S. 25-5-1w3. From an outcrop about ¾ of a mile S.W. of Pickthall. At valley level. Sample 4103 is that of a volcanic ash deposit which can be seen to the west after passing Pickthall a short distance. It is much like the St. Victor ash.

4104–4105—S.E. 27-5-1w3. Taken at an outcrop west of the Flintoft-Wood Mountain road south of the white sandy butte. Sample 4104 is below the band of iron concretions and has no doubt been contaminated through leaching from them. Though its burned shade is of light cream, if the specks are removed would be satisfactory in some pottery wares and for general use where ball clays are employed. This clay checked during cooling. Sample 4105 is the heavy seam of ball clay just above the iron concretions, its raw properties are very much the same as those of 4104. It vitrifies more easily and has about half the absorption at the higher cones. It develops specks from cone 1 up. Would have to be washed but then its burned shade is dark for whiteware. Otherwise it can be used in sewer pipe and other heavy clay products, possibly in some grades of refractories.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	10 + ft.							
4106 Ball Clay	2 + ft.	White and L. greyish	30.8	8.8	04	4.6	10.3	L. cream
					1	4.9	9.0	L. cream
					3	5.7	8.1	L. cream
					5	9.1	4.5	L. blue-stone
					9	8.0	3.7	Nice blue-stone
					10	8.0	2.7	Nice blue-stone, no specks.
Overburden	10 ft.							
Bentonite	3 ft.	Dark						
Volcanic Ash	8 ft.	Whitish						
4107 Ash	3 ft.	Whitish						
Overburden	Heavy							
Very dark clay	?							
4110 Clay	3½ ft.	L. grey	32.8	10.0	04	4.1	8.7	L.cream
					1	5.4	6.7	L. cream
					3	6.6	4.1	Little darker
					5	8.9	.....	Bluest one
					7	9.4	.....	Overfiring
					9	9.2	0.0	Overfiring
4109	2 ft.	L. chocolate	31.8	8.8	04	3.2	10.9	L. cream
					1	5.2	8.3	L. cream
					3	7.6	3.5	L. cream
					5	9.5	0.2	Bluestone clear of specks
4108	2½ ft.	Nearly black	41.2	10.6	04	5.3	13.6	Yellow
					1	7.8	6.6	Yellow
					3	10.9	.....	Light bluestone
					7	11.2	.....	Blistered
Lignitic	3 ft.	.....						

4106—S.E. 27-5-1w3. Taken one quarter mile south of the sandy white butte mid-way along the highway from Flintoft to Wood Mountain. Sample 4106 is that of a type ball clay which vitrifies rather slowly but steadily, but its colour changes rather early in that it starts to bluestone at cone 5 and is therefore limited re its use in whitewares. It might find use as a bond clay or to harden up bodies containing more refractory clays.

4107—S. 2-6-29w2. About a mile N.E. of St. Victor. Sample 4107 was taken as a sample of the lower zone or bed of volcanic ash at the outcrop of same where volcanic ash samples 4007 and 4009 were taken for the report on Sask. Volcanic Ash.

4108–4109–4110—E.½. 14-5-28w2. S.W. from Willowbunch, 2.3 miles from the Catholic school, to the west up the hill past an old coal mine, then south to the coulee. Sample 4108 is highly plastic, shrinks too much and would crack in full size ware if used alone. It offers possibilities for yellow ware and stoneware if the shrinkage is corrected. Sample 4109 is just above the last sample, not quite so plastic but still has too much total shrinkage at cone 5 and higher, it bluestones. Should be blended with a less plastic clay for pottery, brick and other wares. Sample 4110 is of the same type and general properties of the two beds below it. It cannot be used alone, for wares other than possibly by the dry press method.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	Light							
4112	10 ft.	Lead grey	31.2	11.2	04	2.2	12.0	L. cream
Clay					1	2.5	11.4	L. cream
					3	3.1	10.6	L. cream
					5	3.6	9.4	Overfired
					9	3.7	7.7	Overfired
					10	3.6	7.9	Buff
Clay & iron	3 ft.	Rusty						
Silts, sandy	12 ft.	Lighter						
Lignite	Thin	.....						
4111	2½ ft.	Yellowish	26.8	6.4	04	1.8	11.4	L. cream
Clay					1	3.5	9.1	L. cream
					3	5.5	5.4	Little deeper
					5	9.0	0.1	Blue-stoned
					7	.....	.....	Overfired
Overburden	Heavy							
4113	6 ft.	L. grey	35.7	11.6	04	5.3	6.4	Reddish buff
Clay					1	6.3	3.3	Reddish buff
					3	8.0	0.2	Blue-stoned
					5	6.1	.....	Overfired
4114 Clay	1½ ft.	Light greyish						

4111–4112—W.½. 10-5-27w2. These samples taken on the saddle back west of Bonneau Lake and on land of T. Bonneau. Sample 4111 is a stoneware type of clay, of fair plasticity and moderate drying shrinkage. Its firing limit is about cone 5. General uses are, yellow ware, stoneware, in sewer pipe mix, brick, tile and other wares. The main deposit is in the hill at the south end and higher than the saddle back. Sample 4112, this bed of clay is at the top and is more plastic than clay 4111, its dry shrinkage is too high, the burning shrinkages are very low and the absorptions are rather high. For the uses listed under clay 4111, this clay, 4112, would be better if blended with clay 4111 or some other less refractory clay of lower drying shrinkage.

4113—S. 21-5-28w2. On land owned by E. L. Esperance, two miles south west of Spring Lake. Sample 4113 was collected from a small pit where clay had been taken for use as a crude whitewash. It was of good plasticity, the drying shrinkage is too high, burning shrinkages are fair. Might be used for some heavy pottery, though there are clays of better burned shades in the Willowbunch area for yellow ware stoneware.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	Heavy							
Lignite								
4116	2½ ft.	L. grey	31.9	10.5	04	.....	11.3	White
Ball Clay					1	.....	8.7	White
					3	.....	7.9	White
					7	.....	6.1	L. cream
					10	.....	4.8	L. cream Very few specks
Iron zone	.....	Grey & rusty						
4115	2½ ft.	Dark	33.9	8.8	04	.....	14.6	White
Ball Clay					1	.....	12.0	White
					3	.....	10.4	White
					7	.....	6.8	L. cream
					10	.....	5.6	L. cream specks
Clay	.....	Black						
Overburden	10 ft.							
Lignite								
4118	3 ft.	Dark	33.2	8.3	04	.....	15.9	White
Ball Clay					1	.....	13.2	White
					5	10.2	7.0	L. cream
					7	.....	6.1	Deep cream
					10	.....	5.3	Deep cream, specks
4117	3 ft.	Dark	30.8	8.3	04	.....	15.5	White
Ball Clay					1	.....	13.3	White
					5	8.9	8.3	White
					7	.....	7.5	D. cream
					10	.....	7.5	D. cream specks
3904	.....	Creamy white						

4114—W.½. 34-3-24w2. West of the highway where it crosses the valley south of Bengough. Sample 4114, a very small sample of this clay was taken for a colour check only to assist in checking certain beds. It is of the ball clay type. Burned very light.

4115–4116—W.½. 27-3-24w2. West of the highway where it crosses the valley south of Bengough and on south side about one half mile west of Roberts' ranch buildings where a coulee comes in from the south. Sample 4115 is that of a dark coloured blocky clay, is fine grained and had to be dried slowly. The burned draw trials all cracked badly hence could not obtain shrinkages. The absorptions are rather high, colours good other than specks from cone 5 up. General uses those of ball clays. Sample 4116 while requiring less water of plasticity than 4115, the drying shrinkage is higher, the burned trials all air checked. The absorption shows this clay to vitrify more easily than 4115 below it. It is nearly free of iron specks. Its uses would be in most all whitewares though for some wares it does not become dense easily enough.

3904–4117–4118—N.E. 27-5-1w3. On the Kerash quarter and taken at the same deposit as clay 3904. Sample 4117 is a ball clay of good raw properties. The burned trials checked while cooling. It burns a little dark above cone 5, and, does not show much further vitrification at cone 10. Its general uses are those of a rather open firing ball clay. Sample 4118 was sampled as the next 3 feet above 4117, in general there is so little difference between them that they should be worked as one clay for use as a ball clay in whiteware or as a bond or plasticizer to clays of less plasticity.

NOTE:—During the present season's field work, resampling was done and quantities taken of clay beds number 2622, 3909, 3910, 4012 and 4013, see those years for data.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1943.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden 4311 (Old No. 10 and 2615)	Little 12 ft.	Creamy white	25.6	8.7	2	3.8	13.9	Very L pink
					4	5.2	11.3	L. buff
					6	5.4	10.6	Same, specks
					8	6.4	8.0	Same, specks
					10	7.1	6.4	Same, specks
					12	7.0	6.3	Deeper buff, many large specks
Overburden 4312 (Clay Old No. 2613)	Heavy 6 ft.	Nearly white						Pinkish buff L. cream Shade darker Greyish buff Greyish buff Greyish buff Many specks
4313 Shale clay	6 ft.	D. grey to brown	63.4	36.3	2	9.1	4.6	Med. grey
					4	9.2	4.7	Med. grey
					6	9.1	4.5	Med. grey
					8	9.3	4.3	Med. grey
					12	8.7	3.9	*Buff *Long Cooling

4311–S½-33-7-28w2. About midway between Willows and Readlyn at the ball clay pit which has been worked for many years.

NOTE: This was taken as a quantity sample of No. 10 clay for laboratory investigations. This clay is of interest for use in terra cotta bodies, washing and screening did not improve it sufficiently for use in whitewares nor as a paper clay, for the latter purpose it was too gritty and the colour was not suitable.

4312—Sec. 6-7-27w2. Taken from the first large outcrop north of the Verwood cemetery on Highway No. 13. Sample 4312 is the upper 6 feet of original sample No. 2613. While the new sample is somewhat better than the old, this clay is not suited as a ball clay for whiteware. Its general uses are those of No. 10 (4311) above.

NOTE: Test data missing, colour trial only preserved.

4313—S.W. 8-7-27w2. Collected from an outcrop along a valley to the N.E. about ½ mile from the outcrop where 4312 was taken. Sample 4313 in the raw is a flinty clay breaking down into angular pieces. While its water of plasticity is very high it did not exhibit excessive plasticity, the trials required very slow and careful drying to avoid cracking from a high drying shrinkage. When burned to cone 12 there was practically no change in shrinkage or absorption. The colour is poor and the trials air checked some. There are a few specks. This clay is from the same deposit as 3407. Uses for it are questionable.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	30 + ft.							
Lignite	Thin	.....						
4318 Bentonite	5 ft.	Yellowish green						
Lignite dust	Thin	.....						
4317 Bentonitic	3 ft.	D. grey						
Lignite	Thin	.....						
4316 Bentonitic	2 ft.	Black						
4315 Bentonitic	3 ft.	Yellowish green						
Lignite								
4314	3 in.	.....						
Lignite	2½ ft.	L. brown						
Shaley iron zone	3 in.	.....						
Overburden								
4319 A Bentonitic Cap	20 in.	Black						
Overburden								
Volcanic Ash								
Bentonite	6–30 ft.							
4321 Clay	2 ft.	Yellow						
4320	5 ft.	White & Yellowish						
Overburden	Heavy							
Silts								
Shale								
4323 Clay	5 ft.	Light & grey						
4322 Clay	2 ft.	Black						

4314–4315–4316–4317–4318—S. 36-5-1w3. Taken on the south side of the angling road N.W. from Pickthall and 1.5 miles west from the railway crossing. The outcrop is large.

NOTE:—These samples 4314 to 4318 inclusive were taken to test their importance as drilling mud clays and are covered in that report on the Sask. drilling mud clays. The upper seam 4318 is of fair thickness and is fairly high in bentonite. The deposit is close to a rail siding at Pickthall.

4319—S.?. 6-30w2. Taken at a south projecting bare hill about one mile north of Pickthall and a half mile east of No. 2 highway.

NOTE:—This bentonitic clay sample is the black capping material common to many outcrops in the general area. Its interest at time of sampling was that of use as a drilling mud.

4320–4321—N.W. 11-3-1w3. Taken on the west side of the ravine across from the spring at the Spagrud barns. Samples 4320 and 4321 were taken as their possible use as paint clays. Their raw colours are not good enough and their calcined shades are no better. In case the clays are uncovered through the removal of the volcanic ash and bentonite, then they may prove of interest for structural ware, sewer pipe body and crude pottery. They resemble the coloured clays in the "Big Cut" one half mile west.

4322–4323—E.½. 14-5-28w2. S.W. from Willowbunch, 2.3 miles from the Catholic school, following the road west up the hill past an old coal mine, then south to the coulee.

NOTE:—These two samples were taken for clay type test purposes. They are both Willowbunch clays of the yellow ware, stoneware type. See data re samples 4108–4109 and 4110 from the same outcrop.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1943—Continued

Sample No.	Thick-ness	Raw Colour	Per cent.		Burned at cone	Per cent.		Burned Colour
			Water Plast'y	Dry sh'kge		Burned sh'kge	Absorp-tion	
4324 Ochre	2 ft.	Purple to Yellow						
Overburden	200 ft.							
Silts								
Shale								
Lignite								
3916 Ball Clay	3 ft.	Darker						
3915 Ball Clay	2½ ft.	Light & Dark						
3914 Ball Clay	5 ft.	L. grey						
4325 Ball Clay	2½ ft.	Grey	28.6	8.8	04	2.8	13.2	Nearly white
					3	5.1	9.3	Nearly white
					6	6.4	6.0	L. cream
					9	6.6	4.9	L. cream
					12	8.0	2.8	Blue-stoning
					14	7.6	0.0	M. blue-stone
Clay	1 ft.	Black						
Sandstone	20 in.	Grey						
Sandy Clay	10–12 ft.	Nearly white						

4324—S.E. 29-5-29w2. Taken from an old pit wall up the slope on the McGillis farm a mile and a half south of St. Victor. Sample 4324 was that of a low grade ochre, formerly used locally to paint a few barns. The deposit is thin and by means of bored test holes it was found over a very small area only. It is of little further interest.

3914–3915–3916–4325—S.E. 36-3-24w2. Approximately two miles east from Highway 34 where it crosses the Big Muddy Valley south of Bengough. The outcrop is on the north side of the valley and near the base of the very deep valley wall. The outcrop is near the east line fence of the quarter. Samples 3914, 3915 and 3916 are dealt with under the report for year. They are all ball clays, but like 4325 just below them they are so low down in the valley that the only possible way of their recovery would be by mining methods underground. Sample 4325 is a normal type of ball clay not unlike the beds above it. It is hard and breaks out in blocky form.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	Heavy							
Lignite								
Clay	2 ft.	Dark lignitic						
4328	2 ft.	Greyish	41.8	13.7	04	.....	14.1	Nearly white
Ball Clay					01	.....	7.6	Nearly white
					3	.....	6.8	L. cream
					6	.....	3.8	M. cream
					9	.....	1.8	M. cream
					12	.....	0.0	Greyish Few specks.
4327	20 in.	Very light	38.2	10.3	04	.....	18.4	Very light
Ball Clay					01	.....	9.1	Nearly white
					3	.....	8.5	Nearly white
					6	.....	4.9	L. cream
					12	.....	1.1	M. cream Few specks.
4326	2 ft.	Grey	38.6	11.6	04	.....	13.8	Nearly white
Ball Clay					01	.....	4.6	L. cream
					3	.....	2.6	D. cream
					6	.....	1.5	D. cream
					12	.....	1.0	Greyish Few specks.
Clay	2 ft.	Black, not sampled						
Lignite	1 ft.	Brownish						
Sandy clay	4 ft.	Grey						

4326–4327–4328—S.E. 36-3-24w2. These three samples taken a little to the west of the above samples, and on the east face of the first draw coming into the main valley from the north. Sample 4326 of ball clay proved very difficult to dry safely, a second set of trials had to be made. All cracked during cooling from the kiln. While it was possible to measure absorption, the burned shrinkages could not be measured. This clay vitrified quite rapidly becoming of low absorption at cone 6. The colours are common to ball clays. The seam is too thin to be worked alone by mining methods, the only means possible. Sample 4327 has a somewhat slower rate of vitrification at the lower temperatures than the clay below it 4326, at cone 12 they have the same low degree of absorption. This clay also cracked badly during the cooling such that shrinkage measurements were impossible in the burned state, but absorptions were possible. It is a ball clay of fair properties only. It is very hard in the deposit. Sample 4328 is a ball clay of higher plasticity and drying shrinkage than the clays below it and had to be remade a second time to obtain a set of uncracked dry trial pieces. They all cracked badly during cooling therefore shrinkage data was not obtainable. It could very well be worked with clay 4327 below it.

NOTE:—Owing to the cost of mining these clays, their distance from rail, and, in view of the presence of similar ball clays near or on rail, there is little likelihood of their being of early interest for development.

REPORT ON PRELIMINARY CLAY SAMPLES COLLECTED DURING 1944.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden Sandstone 4401 Clay River	30 ft. 6 ft.	Bluish	38.1	14.0	010 07 04 1 3	..... 5.9	7.3 2.0 1.9 0.8	D. cream Light tan Dark tan Dark tan Greyish tan
Overburden 4402 Shale	Little 24 in.	Greyish	50.2	19.1	010 07 04 1	.... Bloated	10.3 3.8 0.0 Bloated	Light red Dark red Dark red Brown red
Overburden 4403 Shale	Little 5 ft.	Greyish & Rusty	56.3	18.0	07 04 02	6.4 9.6 10.8	8.43 1.9 0.0	Light red Dark red Brown red
Overburden 4404 Shale	Little 10 ft.	Greyish Rusty	56.4	17.5	07 04 02 1 3	6.4 9.6 11.4 Bloated O'fired	9.1 1.9 0.0 Bloated O'fired	Light red Dark red Dark red ....
4405 Marl	8+ ft.	Buff to white	.....	.....	.....	.....	.....	.....

4401—Unsurveyed Lands. On north side of Red Deer River at the silica sand outcrop just below "Jelly Berry" island about eleven miles north of Armit, Sask. Sample 4401 occurs just beneath the silica glass sands. Where exposed and damp it is of a bluish shade and is plastic. Its total depth could not be obtained in that it passes below the water level. Its drying shrinkage is too high and cracked. That of burning is better. In general it is a yellow ware-stoneware type of clay. It has some interest as a drilling mud. At present it is inaccessible to transportation.

4402—43-3w2. Taken on the west bank of Etomami River about 10 miles down stream from Bertwell (Kakwa) and near the west end of the bridge, north. Sample 4402 is a fissile shale, greyish to dark in shade, it has an abnormally high water of plasticity and drying shrinkage. It holds little if any interest for clay wares. It can be bloated and might thus be useful.

4403—Taken about 5 miles down stream (Etomami) from Bertwell and near a small logging bridge, a quarter of a mile west of highway No. 9. Sample 4403 is of the same properties as 4402 other than it did not bloat at cone 1. It is of very little interest for any of the usual uses for shale.

4404—S.½. 5-42-4w2. At the north end of the C.N. Rly. bridge over the Etomami River at Bertwell. Sample 4404 has the same defects as samples 4402 and 4403. It, like the former, bloats and therefore offers promise for use as such in light weight concrete. Furthermore these shales where weathered to clay might be worthy of testing for use as drilling muds.

4405—At farm of Stanley Haymen about four miles north of Pelly. This is marl from a very large deposit and is still in process of formation.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	None to heavy							
4406 Bentonite	2 ft.	Yellowish	.....	.....	.....	.....	.....	.....
4407 Shale	6+ ft.	Black	58.2	6.5	07	10.0	29.6	Med. buff
					04	12.1	26.9	Darker buff
					02	12.9	21.0	Darker buff
					1	13.7	15.4	Dark buff
					3	.....	.....	Brownish
4408 Bentonite	3 in.	Yellow	.....	.....	.....	.....	.....	.....
Overburden Soil	10 ft.							
Shale								
4409 Shale	20 ft.	Yellowish Grey	39.5	10.2	07	0.4	23.1	Salmon
					04	0.8	22.4	Salmon
					02	5.0	14.4	Light red
					1	12.4	0.0	O'fired
Overburden Silts	0–10 ft.							
Shale								
4410 Marl	15 in.	White	.....	.....	.....	.....	.....	.....

4406—Taken about four miles east of Pelly and south of the Doukhobor bridge over the Swan River. The outcrop is along a small tributary entering the Swan from the south. Sample 4406 is a bentonite and could not be tested as a clay. It occurs in black shale, and from a disturbed pitching bed of same where sampled on the east side of the creek. The general area should be further prospected.

4407—This bed of shale is just below the 4406 bentonite. Sample 4407 is a sample of the black shale just below the bentonite. It is unusual in its high per cent. of water of plasticity and its low per cent. of drying shrinkage. It lacked plasticity, was difficult to mould. The burned absorption is high and the shades fair. It will require further work to prove its usefulness.

4408—This thin seam of bentonite occurs in the black shale bed three feet below bentonite 4406. Sample 4408 is a thin band or seam of yellowish waxy bentonite of the same sort as 4406. It was not tested as a clay.

4409—E.½. 5-30-22w1. About two miles along Highway No. 5 west of Kamsack, and on the north side of the road near the top of the hill after crossing the bridge over the Whitesand River. Sample 4409 is a sample of young rather soft shale, the plasticity was good, its drying shrinkage needs reducing. The absorption is high other than for common brick, backing up tile and drain tile. The colour or shades are weak.

4410—Eastend, Sask. This sample taken 16 miles westward from Eastend to Kealey Springs. Sample 4410, at the point of sampling there are numerous showings of white marl, a small sample only was taken.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden No. 14 Clay 4411 Sandy	Heavy 4 ft.	Greyish white	18.9	2.8	010 04 1 8 10	−0.5 0.0 0.7 5.1 6.3	18.4 17.4 16.3 11.6 9.5	L. pink L. pink buff Little darker L. blue-stone Med. bluestone, specks
Whitemud								
Overburden Silts Shale 4412 Clay	40 ft. 6 ft.	Light	27.0	6.4	010 04 1 6 8	0.0 2.1 5.7 7.7 9.5	18.9 15.2 7.9 4.3 0.0	L. pink buff L. pink buff Darker Darker Bluestone
4413 Sandy	4 ft.	Light	22.5	5.3	010 04 1 6 10	0.0 0.0 1.9 3.0 6.2	16.1 14.5 11.8 9.2 2.5	Chalky white L. pink buff Darker Darker Stoneware Grey

4411—S.½. 17-6-22w3. Taken at the No. 14 stoneware clay pit. Sample 4411 was a sample of the kaolinized sandy Whitemud from just below No. 14 plastic clay. Its general use would be as a blend with No. 14 to reduce the shrinkage of that clay and to raise its burning temperature for salt or stoneware glazes.

4412–4413—S.E. 6-7-21w3. Alberta Clay Products Ltd. Clay Pit, N.W. of Eastend. Sample 4412 was taken as a sample of the plastic stoneware clay. It had good plasticity, worked well, it vitrifies rather slow up to cone 6 then its rate increases rapidly. It is used in sewer pipe body and that for stoneware. Sample 4413 was of the kaolinized sandy Whitemud near the floor of the pit. It was of small grain size, moulded well and dried safely. It is used with the more plastic clays above to improve their properties.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	20 ft.							
4415 Clay	5 ft.	Dark	46.0	18.9	010	.....	14.1	L. orange buff
					07	.....	8.8	Much darker
					02	.....	3.0	Darker
					3	.....	1.2	Brownish red
4414 Clay	5 ft.	Purple Grey	31.4	9.0	010	1.1	18.2	L. cream
					02	.....	14.9	Very L. cream
					1	6.1	10.5	Little darker
					10	.....	6.5	Little darker
Top of used clays								
Overburden	Very little							
4416	12 ft.	.....	.....	.....	.....	.....	.....	.....
Overburden	10–15 ft.							
4417	2½ ft.	Greyish & Purple	35.3	10.6	010	.....	19.8	Chalky white
					02	.....	14.9	Chalky white
					1	.....	8.5	Little darker
					8	.....	5.5	Little darker
					10	.....	4.6	Little darker
4418	12 ft.	Greyish	30.6	8.9	010	2.3	19.1	Slightly pink
					02	.....	14.4	Chalky white
					1	.....	9.5	Little darker
					8	.....	6.2	L. cream
					10	.....	4.8	L. cream specks
4419	10 ft.	White	.....	.....	.....	.....	.....	.....

4414–4415—S. 8-7-21w3. At the clay pit of The Medalta Potteries Ltd. north of Eastend. Sample 4414 is a dark purplish clay-shale now part of the overburden. It had a nice degree of plasticity, dried safely and became steel hard at cone 010, the burned shades are light cream other than specks at cone 8 up. Five of the trials cracked through sudden cooling. Its absorptions are too high to be used alone for pottery but should be useful in heavy clay product body mixes. Sample 4415 is just above 4414 and is far more plastic and sticky. The drying shrinkage is high and unsafe. All trials were cracked, the rate of vitrification is too rapid and the colours are poor. Studies re its use with 4414 are desirable. A suitable mix for face brick should be possible.

4416—N.W. 29-9-12w3. About one mile east of the elevators at Gouverneur. Sample 4416 was that of quartzite pebbles, 1 inch to 6 inches in diameter.

4417–4418–4419—S.½. 33-7-28w2. Midway between Willows and Readlyn and south of the railway at the ball clay pit. Sample 4417 was a new sample taken of ball clay No. 92 and that of 2670 reported in the J. Am. Cer. Scy. 1929. This is a high grade ball clay useful in whitewares. Carloads have been taken to potteries in Ohio. The present samples cracked badly during sudden cooling due to density. It became steel hard at cone 07. Sample 4418 occurs just below the above bed, and at the point of sampling there are numerous small iron concretions. The bed is old number 92A and 2669. It does not burn to as light shades as 4417 and unless the clay can be freed of the concretions it is of questionable value. The concretions may not be common elsewhere on the property. Sample 4419 was taken as a quantity sample of No. 10 clay which occurs at the base of the clay pit. It has been widely used as one of the clays in sewer pipe and face brick bodies. It is only moderately refractory.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1944—Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	0–10 ft.							
Lignite 4420	10 ft.	Greyish	32.8	10.8	010	1.2	17.0	Chalky white
Clay					02	.....	13.0	Chalky white
					3	.....	10.6	Very L. cream
					8	.....	7.3	Very L. cream
					10	.....	5.6	Slight blueston-ing specks
Iron Con-cretions								
Overburden	10 – ft.							
Lignite 4421	8 ft.	Greyish	32.8	10.3	010	.....	19.3	Chalky white
					02	3.6	15.9	Chalky white
					3	.....	11.5	Chalky white
					8	.....	8.5	Chalky white
					10	.....	7.2	Chalky white Few specks
Iron Con-conretions								
Overburden	10 + ft.							
Lignite 4422	8 ft.	Greyish	.....	.....	.....	.....	.....	.....
Clay								

4420—S.E. 12-8-29w2. This deposit is about three quarters of a mile north of the Medalta pit at Willows. Sample 4420 is a ball clay only slightly different in absorption to clay 92A (4417), its purity and burned shades are not so good as that clay, being more like 4718 in those respects. It is a bed of good depth, some portions may be more pure than the total sampled.

4421—N.W. 7-8-28w2. On the Corsolls' farm north east of the above sample on Sec. 12. Sample 4421 is a sample of ball clay which is very much the same as clay No. 92A (2670) in that it burns white at all cones, and becomes steel hard at cone 010. Its uses are those of a good white burning ball clay.

4422—N.E. 1-8-29w2. N.E. of Willows at the ball clay pit of the Medalta Potteries Ltd. Sample 4422 was taken for general use as a ball clay in the Ceramic department. It was taken about 300 feet N.W. of where the pit was opened in 1926 and where sample 2622 was collected. See report on it in J. Am. Cer. Scy. 1929.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	Variable							
Shale								
Lignite								
4426 Clay	4½ ft.	Lighter Brownish	34.3	9.1	02	.....	17.4	Chalky white
					3	.....	14.8	Chalky white
					6	.....	8.4	Chalky white
					8	.....	6.8	Very L. cream
					10	.....	5.6	Two shades deeper
4425 Clay	4 ft.	Brownish	34.9	9.4	02	3.8	18.4	Chalky white
					3	7.3	12.3	Chalky white
					6	8.3	10.7	Chalky white
					8	.....	9.5	Very L. cream
					10	.....	8.4	Little Deeper cream
4424 Clay	2½ ft.	Nearly white	38.0	8.6	02	4.0	26.4	Chalky white
					2	4.4	22.7	Chalky white
					6	8.7	14.0	Chalky white
					10	11.0	9.1	Chalky white
Sands	10 ft.	Off shade, rusty						
Lignite								
4423 Sandy white	15 ft.	Fairly white	20.6	4.3	010	3.8	19.3	L. pink
					02	3.9	18.6	Chalky white
					3	4.1	18.1	Chalky white
					6	4.4	17.3	Chalky white
					10	4.9	15.8	Little darker Some specks

4423–4424–4425–4426—N.E. 27-5-3w3. To the west of the Flintoft-Wood Mountain road and about four miles south of the former place. Sample 4423 represents the base of the outcrop, above it are some impure sands and lignitic material unsampled. This sample is a typical kaolinized sandy Whitemud and of no unusual properties, it is worthy of a washing test for its interest as a source of kaolin. There was some greenish scum present. Sample 4424 is a ball clay which remains white at the higher temperatures and is practically free of specks. The old number of this clay is 3904. It vitrifies rather slowly and would not prove as useful as a bond clay as some of the other ball clays in the same area. It was tested out as a clay for use in metal enamels. While of interest, it did not measure up to enameling clays in use. Sample 4425 occurs just above the 4424, it is very much like that clay other than in raw colour and its rate of vitrification is better, the absorptions are lower at the same cones. There were a few specks. As ball clays this clay and 4424 could well be worked as one. Sample 4426 is a continuation of sample 4425 and is a little lighter in shade. Its raw properties are the same. From cone 6 on its vitrification is greater than the clay below it. At cone 10 it is just a little darker and is not quite so speck free as are clays 4424 and 4425. For some whiteware uses the three seams could be taken as a single clay. The general area where these clays occur offers very favourable prospects of being one of the most important ball clay areas of the province.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
4501 Shale	6 ft.	Yellow	28.8	7.8	010	0.4	23.6	Light red
					04	1.3	21.4	L. buff
					02	.....	20.7	Greyish-buff
					1	.....	13.8	Greyish-buff
					3+	.....	Melting	Greenish
4502 S. stone concretions	2½ ft.	Greyish						
4503 Shale	4½ ft.	Yellow	25.2	5.4	010	0.6	26.5	Pinkish-red
					04	0.5	27.1	L. yellow
					3	1.6	27.5	Greyish yellow
					6	Melted	Melted	Green slag
4504 Ironstone Concretions	2½ ft.	Rusty						
4505 Shale	4½ ft.	Greyish	21.5	3.4	010	†−0.2	29.0	Light red
					04	†−1.1	31.4	Greyish-buff
					3	†−0.3	30.7	Greyish-buff
					6	Melted	Melted	Greenish slag
Lignite Blue Shale †—Expansion	2 ft.							
4506 Shale	10 ft.	Yellow	23.4	5.8	010	0.6	20.6	Pink-red
					02	1.1	21.8	L. yellow
					3	.....	20.6	L. yellow
					6	.....	Melted	Green
4507	12 ft.	Yellow	23.5	5.5	010	†−0.1	22.7	Pink-red
					04	0.2	23.8	L. yellow
					02	0.6	23.8	L. yellow
					3	.....	23.9	L. yellow
					6	Melted	Melted	Green

NOTE:—All samples listed between main horizontal divisions are from the same deposit and in the order as shown.

4501–4502–4503–4504–4505—Clay pit at Estevan brick plant, as worked during 1944 Sample 4501 is the uppermost bed though is not used alone but mixed with the clay from beds 4903 and 4905. While the concretionary bands when present are discarded, they are in places absent and are replaced by shale which is added to the general mixture. This particular clay has for many years been used for the production of common brick and structural tile. It has a low total shrinkage but like most other calcareous clays it has a high absorption up to very near its sudden melting point. Sample 4502 is from a zone of sandstone concretions, not used. Clay 4503 is so like 4501 that it requires no further description. Clay 4505, this bed of clay is more sandy and coarser grained than those above it. It expands during burning and if used in excess in the total mixture would cause a weak punky product.

4506—To the north of the above pit and at an old working face near the cemetery. Clay 4506 is very much like the clays above in all of its properties, very low shrinkage but high absorption. It is not suited to other than the more common wares.

4507—From the old abandoned pit south east of the brick plant. Clay 4507 is the same as clay 4506 other than of a higher absorption. It was used for many years for stiff mud common brick manufacture.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
4508	8 ft.	Blue	44.5	All trials cracked while drying	010	.....	9.0	L. salmon
					07	.....	4.0	Red
					04	.....	2.2	Red
					1	.....	0.7	Brown
4509 Shale	1½ ft.	L. grey	.....	.....	.....	.....	.....	.....
4510 Sandy Shale	4½ ft.	Greyish	42.6	11.5	010	†−0.3	21.5	Light red
					04	*−0.7	20.0	Reddish
					02	0.0	18.1	Reddish
					3	Starting over	to Brown fire	
4511 Blue Shale	8 ft.	Greyish blue	.....	.....	.....	.....	.....	.....
4512 Shale	14 in.	Black	54.5	17.6	010	4.6	28.0	Salmon red
Overburden	Light							
4514 Clay	6 ft.	Grey to dark	35.4	13.0	010	1.0	12.2	L. cream
					04	4.4	6.1	M. cream
					1	5.8	2.2	M. cream
					3	.....	.....	Bluestoning
					6	Bloated	Bloated	
4513 Sandy clay	3 ft.	Greyish white	20.4	4.5	010	†−0.4	16.2	Salmon
					02	0.0	15.0	Light buff
					3	0.5	14.6	Darker buff
					10	2.0	12.1	Slight bluestone

NOTE:—These clays gradually increase in absorption at the lower cones.

4508—At west side of old pit and south of the plant. Clay 4508 is a sample of the Estevan blue shale. While used for many years in the production of red face brick by the dry press method, it offers little promise by the stiff mud method unless specially treated. All trials above cone 010 were bloated. It may have use for "Haydite".

4509—Taken from between two thin coal seams just above 4508. Clay 4509, this sample was taken as of possible use for Haydite manufacture, and was not tested as a clay.

4510—From a large outcrop near the Souris River, about three quarters of a mile south of the brick plant. Clay 4510 was taken from a sandy zone of the Estevan beds. It was a little short, dried safely and burned with a high absorption, then failed rather rapidly. There was much dryer scum and of a rather weak burned colour.

4511—Taken in the old Pit, south across from the boiler house of the brick plant. Clay 4511, all of the trials of this sample cracked badly during drying. Bloated in the burn. See notes re sample 4508 for this sample as well.

4512—Taken at outcrop south of the brick plant barn. Clay 4512, this clay cracked very badly while drying, had much dryer scum, and all trials were bloated from cone 02 up. It holds no interest for clay wares, but would bloat well for Haydite, but the seam is too thin.

4513-4514—Taken just above the Souris River water level at the bridge south of Estevan, highway No. 47. Clay 4513 is a type of Whitemud which corresponds to the sandy zone of the Willowbunch formation. It had fair plasticity, dried safely, burns to light shades and is quite porous at cone 10. It should be blended with clay 4514 just above it for face brick, and other structural wares. Also has possibilities for yellow ware and stoneware products. Clay 4514 is a plastic clay which like the sandy clay below it is undoubtedly a member of the Willowbunch formation. It is plastic but rather sticky and has too much shrinkage during drying. The burned shrinkage is better but this clay should be blended with the clay below for the uses suggested. It bloats from cone 3 up.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	0+ ft.							
4515	4+ ft.	Very light	34.2	13.0	010	0.0	14.3	L. cream
Clay					04	2.7	8.6	L. cream
					1	4.8	3.4	L. blue-stone
					5	4.0	0.0	Deep bluestone
					10	.....	0.0	Deep bluestone
Overburden	40 ft.							
4518	2 ft.	L. grey	22.5	5.0	010	0.6	21.4	L. pink
Shale					02	0.8	22.2	L. cream
					1	.....	22.0	L. cream
					3	2.0	21.1	D. cream
Silts	4 ft.							
Lignite	2 ft.							
Lignitic	15 in.							
4517	4 ft.	L. grey	27.8	9.3	010	0.4	11.8	Light red
Shale					04	2.2	7.8	Lght red
					02	6.9	3.2	Light red
					3	Overfired		Greenish
Iron zone								
4516	2½ ft.	Greyish	.....	.....	.....	.....	.....	.....
Shaley clay								
Iron Concretions								
Silts								
4519	2 ft.	White	.....	.....	.....	.....	.....	.....
Vol. Ash								
4520	4 ft.	Greyish white	.....	.....	.....	.....	.....	.....
Vol. Ash								
4521	5 ft.	White	.....	.....	.....	.....	.....	.....
Marl								

4515—Taken on west side of No. 47 highway at foot of hill on the south side of the Souris Valley south of Estevan. Clay 4515 is a further sample of the plastic Willowbunch (?) clays and is no doubt an extension of deposit 4514 to the north. The present sample shows better burned shades than that clay, and does not bloat or overfire at cone 10. It should be blended with a sandy clay like 4513.

4516–4517–4518—From an outcrop of about 100 feet of Ravenscrag beds of shale, silts, lignite and sandstone facing west on Short Creek about one and one quarter miles S.W. of Roche Percee. Clay 4516 is a fine grained plastic clay of good working properties, drying shrinkage a little too high, scums badly. Burning properties good but weak as to colour. General uses common structural wares only. Clay 4517 is a typical calcareous clay of good working properties but of high absorption. General use would be those of clay 4516. Clay 4518 is a thin seam of calcareous clay sampled for testing as a rock wool material. It gave negative results.

4519–4520—N.W. 11-3-1w3. At the T. Spagrud farm west of Rockglen. Samples 4519 and 4520 are of volcanic ash for testing as rock wool materials. The latter sample, 4520 is the same as earlier number 3726.

4521—N.W. 16-2-2w3. At the A. G. Morrison farm buildings. South of Canopus. Sample 4521 is a sample of marl for testing as a rock wool material. The deposit was first sampled as No. 3132.

4522—S.E. 17-6-22w3. One half mile south of Knollys. Sample 4522 is a sample of bentonite, is a select section of No. 325 bentonite for study purposes.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
4522 Bentonite	2 ft.	Olive green	.....	.....	.....	.....	.....	.....
4523 Marl & clay	12 ft.	White	.....	.....	.....	.....	.....	.....
Overburden	2 + ft.							
Silica Sand	8 in.	White Very fine						
4526	5 ft.	White	.....	.....	.....	.....	.....	.....
Silica sand								
Sand	7 in.	Mixed						
Not Taken								
4525	3 ft.	White	.....	.....	.....	.....	.....	.....
Silica sand								
4524	3 ft.	White						
Lake	30 ft.	below						
4524–A Clay	?	Blue	.....	.....	.....	.....	.....	.....

4523—Located 14.8 miles N.W. of Eastend on the north side of the road to Kealey springs. Sample 4523 is a bore hole sample of marl, though there are numerous showings through gopher diggings. Sample for use in rock wool study.

4524–4525–4526—Wapawekka Lake east of Lac la Ronge. This deposit is the most northerly of the high white silica sand cliffs on the east shore of the lake. Samples 4524–4526 were collected from a deposit first examined by McInnes, Geol. Surv. Can. Sum. Report 1909, and by the writer in 1921 and again in 1945 with C.A.L. Hogg. Since 1921 there have been several slips or slides which have covered the lower beds, and mixed some of the upper ones at the face. Were sands not so far removed from transportation they would be of interest for glass making and other ceramic uses.

4524–A—Taken a little to the south of the above sands and near the mouth of a small stream. See location of sands and clay on map from a 1921 Survey made by Col. A. C. Garner, D.S.O. Clay Sample 4524–A was taken to check with clay 441 (4401) which occurs under the silica sands on the Red Deer River north east of Hudson Bay (Jct.). Both clays occur below the sands and are of the same general type. Light burning, of yellow ware to stoneware shades.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden Sand	4 ft.	Yellow						
Coarse hardened sand	1 ft.	Iron stained						
4530 Coarse sand	1 ft.	White	.....	.....	.....	.....	.....	.....
4529 Kaolin & sand	2½ ft.	White	.....	.....	.....	.....	.....	.....
4528 Kaolin & sand	2½ ft.	White	.....	.....	.....	.....	.....	.....
Rusty Sands	3 ft.	Not taken						
4527 Kaolin & sand	3 ft.	White Some stain	.....	.....	.....	.....	.....	.....
4531 Kaolin & sand	2½ ft.	Yellowish	.....	.....	.....	.....	.....	.....
4532 Shale like Water Level	1 ft.	Greyish	.....	.....	.....	.....	.....	.....

4527–4528–4529–4530–4531–4532—Pipestone Lake, Wapawekka Hills. These samples are kaolinized sands first discovered in 1921 at the mouth of the second small stream entering the lake from the south after passing eastward through the "Narrows" from Wapawekka Lake. Small samples only were collected for the present study. Sample 4527 is the first zone of the kaolinized sands below a heavily iron stained bed of the same sands and was discarded. The present sample when carefully washed by elutriation gave a yield of 10.9 per cent. kaolin, when burned at cone 10 the shade was a clear slightly tinted white. Sample 4528 was taken from above the iron stained sands, and is very white. The kaolin yield by elutriation was 12.1 per cent., and when burned at cone 10 it was clear and much lighter in shade than 4527. Sample 4529 is above the last sample and is white, the yield of kaolin when washed was 15.3 per cent., the highest of all samples from this deposit. At cone 10 it fires to a clear tint, slightly better than 4528. Sample 4530 is the uppermost bed sampled and is only 1 foot thick. The kaolin yield was 10.8 per cent., practically the same as 4527. At cone 10 it is clear and of a high order as to whiteness. Sample 4531 was taken just below 4527 and has a little of the stain from that bed. The kaolin yield is very low being 5.2 per cent., but it ranks highest in whiteness of all samples when fired at cone 10. Sample 4532 was from a small bore hole test made in the semi-hard shale like material below the kaolinized sands which were deposited on top. This material 4532 is fine grained, greyish shade and becomes nicely plastic when ground and tempered. It is a clay which is light burning in colour at lower heats, then bluestones lightly at cone 10, not unlike some ball clays.

NOTE:—The occurrence of this clay and the kaolinized sands above are of real interest for further geological and ceramic study.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	Excessive							
4535	4½ ft.	L. sandy	27.3	11.2	010	0.6	26.0	Light red
Shale					04	0.7	26.0	Grey red
					02	.....	25.6	Grey red
4534	2½ ft.	Darker	43.0	14.0	010	1.7	15.4	Salmon
Shale					04	4.3	10.9	Light red
					02	.....	5.9	Slight bloating
Lignite	Thin							
4533	4½ ft.	Light greenish	40.4	15.0	010	0.2	9.9	Yellowish
					04	2.0	6.2	Very light red
					02	.....	5.3	Bloated
Overburden	20 ft.							
4538	7 ft.	Dark	34.0	13.2	010	0.3	9.0	Yellowish red
Shale					04	4.0	3.8	Darker red
					02	5.3	1.3	Same red
4537	4 ft.	Yellowish	28.0	7.8	010	−0.6	18.0	Med. red
Shale					04	0.0	16.1	Darker red
					3	1.2	13.5	Darker red
4536	3 ft.	L. grey	26.5	6.6	010	−0.1	19.8	Yellowish
Sandy shale					04	0.2	18.2	Med. red
					3	1.5	14.4	Dark red

4533–4534–4535—S. 24-39-23w3. About five miles south of Unity and one quarter mile north of Bata well No. 11. These clays are in the Belly River Beds. Sample 4533 is a highly plastic clay of very high total shrinkage. While it works well it would crack in full size plastic wares. It might be used dry pressed for brick. Its best use would be for Haydite, (bloated clay). Sample 4534 is little better than clay 4533, other than a better red. It scums very badly during drying. Remarks above are the same for this clay. Sample 4535 is a sandy clay of fair working properties but its drying shrinkage is high. Its absorption is very high at all cones and colour is weak. Alone it is of little interest.

NOTE:—Samples 4533-4534 and 4535 were taken from the base of a slide at Valley level, above this slide is a second one plus nearly fifty feet of cover before reaching the outcrop where samples 4536–4537 and 4538 were taken.

4536–4537–4538—Same location as above but near top of valley wall above the slides. Sample 4536 is a semi-sandy clay of good properties other than the absorption is rather high. It burns to a nice red, flashes easily and has promise of being useful for brick and tile, but should be mixed with a clay like 4538. Sample 4537 is practically the same clay as 4536 and should be used in the same way, that is added to a more plastic clay. Sample 4538 is a plastic fine grained clay, works well, has too much drying shrinkage, but reasonable burning shrinkages. It burns to good shades of red for face brick and other structural wares. Should be blended with the sandy clays below it. There are some iron-stone concretions and gypsum crystals present in this bed. It can be bloated easily.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1945—Continued

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	40 + ft.							
4543 Shale	4 ft.	L. brown	39.0	16.0	010	−0.6	11.3	Salmon
					04	2.8	6.6	Med. red
					1	4.6	2.2	Darker red
4542	6 ft.	Chocolate	37.7	13.0	010	−0.8	13.4	Salmon
					02	3.8	8.4	L. red
					1	4.2	7.8	L. red
4541 Shale	1½ ft.		29.5	8.5	010	−0.4	15.6	Salmon
					02	1.6	12.4	L. red
					1	1.9	11.8	L. red
Shale Sandy	1 ft.	Light						
	1½ ft.	Greyish white						
4540	1½ ft.		33.1	10.4	010	0.4	19.8	Med. red
					02	4.8	12.2	Med. red
					1	4.8	12.1	Med. red
Iron Concretions	1½ ft.							
4539 Sandy shale	10 ft.	Greyish	30.6	10.4	010	−0.5	23.2	L. red
					04	0.0	22.2	Med. red
					1	1.2	19.2	Med. red

NOTE:—Taking these clays as a whole there is the possibility of developing a good red burning body for stiff mud structural wares. These or their equivalent beds should be looked for near transportation at Unity.

4539–4540–4541–4542–4543—S.E. 11-39-23w3. At a large south facing outcrop about one mile south of End lake. Sample 4539 while plastic is too sandy to be used alone but would be useful with clays like 4542 and 4543. Has some scum. Sample 4540 is a nice red burning clay and of good properties other than the absorption should be lower. It bloats easily and would be useful for "Haydite". Bed is too thin. Sample 4541 has good working properties, dried safely, scums rather badly, absorption high, bed is too thin, does not bloat due to sandy nature. Useful to blend with the clays above, 4542 and 4543. Sample 4543 is fine grained highly plastic, would likely crack during drying in full size ware. Its burned shades of red are fairly good, it flashes easily and care would be necessary to avoid bloating, would be a good material for that purpose.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1947.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden								
4701	.....	Grey	29.0	7.6	010	1.2	25.2	L. brick red
Sandy Shale								
(Estevan)					04	2.2	.....	Light buff
					3	7.3	9.0	D. buff
					5	12.2	2.0	O'fired
4702	6 ft.	Greyish	38.5	14.2	010	0.2	14.4	L. brick red
Shale								
(Estevan)					07	2.5	15.2	L. brick red
					04	4.0	7.5	D. grey-ish red
					02	.....	.....	O'fired Bloated
Overburden	Little							
4703	15 ft.		28.3	9.7	010	0.4	16.3	L. brick red
Clay								
(?)					04	0.9	14.5	Med. red
					1	4.2	7.2	Dark red
					5	5.1	2.8	Very dark red
Overburden	50 ft.							
4704	.....	White	30.2	8.0	010	1.4	20.5	Pinky cream
Sandy								
Whitemud					04	1.9	19.8	Whitish cream
					3	4.1	15.6	L. cream
					10	4.8	13.4	L. cream specks
4705	.....	White	.....	.....	.....	.....	.....	.....
Sandy								
Whitemud								

4701–4702—N.W. 13-5-13w2. At C.N. Rly. trestle over Jewel Creek east of Goodwater. Sample 4702 taken 125 feet east of 4701. Sample 4701 has a fair degree of plasticity, dried safely, burns buff rather than red, fails rather suddenly above cone 3, only suited for common brick and like wares. Sample 4702 this clay is very much more plastic, gives trouble in drying, burns red and bloats badly from cone 02 up. Only suited as a bloating material.
4703—N.E. 14-5-13w2. In a cut bank north of the railway opposite creek diversion. Sample 4703 is a clay of good working properties, dried without cracking. Burns with low shrinkages to fair shades of red, but all trials were scummed and showed light splotches, no doubt from gypsum crystals.

4704—N.W. 6-5-4w3. Taken near a butte and about 700 feet from the outcrop where sample 4616 was taken. East of Fir Mountain. Sample 4704 is a kaolinized sandy Whitemud and is of more interest as a source of kaolin than as a clay in its natural condition. It is refractory but too siliceous for general use as such. In the past this deposit and others in the general area have been considered as blocks of the Whitemud out of place, that is transported or badly disturbed.

4705—Taken further east in the same valley as sample 4704. Sample 4705 was lost before shipment to the Ceramic Laboratory.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	Heavy							
4706	20 ft.	Off shade	18.5	3.4	010	0.3	16.6	Pinky
Sandy		White						cream
Whitemud					02	0.7	16.1	M. cream
Stoneware					5	1.0	14.5	Greyish
Clay					10	2.6	9.8	Darker specks
4707	20 ft.	Brown	36.8	.....	.....	.....	.....	.....
Overburden	Little							
4708	12 ft.	White?	29.6	13.4	010	.....	23.0	L. brick red
Sandy					04	.....	22.6	Med. dark red
					1	.....	18.1	Brownish red
					5	.....	10.5	Very dark red
Overburden	3 ft.							
4709	.....	Grey	27.6	.....	010	.....	18.6	Very light red
Sandy					04	.....	17.7	Med. red
					1	.....	14.1	Dark red
					5	.....	7.9	Very dark red O'firing
Overburden	None							
4710	12 ft.	Greyish	18.5	3.7	010	0.3	16.1	Fairly white
Sandy		White						
Whitemud					02	0.4	15.4	Fairly white
					1	0.4	14.6	Specky white
					5	0.8	14.0	Specky white
					10	1.1	12.4	Specky white

4706—S.½. 17-6-22w3. This is one half mile south of the Knollys siding. Sample 4706 is a coarse grained sandy bed just below No. 14 plastic stoneware clay. This sample is too low in clay substance to use alone. Its only value is for use with clay No. 14 or other plastic clays. Its clay yield would be very low.
4707—N.E. 16-6-13w2. About 6 miles west of Halbrite and on the west side of Roughbark creek. Sample 4707, this clay was highly plastic and sticky. It cracked very badly in a few minutes after moulding. Is of no interest for clay products.

4708—N.E. 25-6-13w2. This is about three miles west of Halbrite in the valley of the Souris and north of the road about one mile. Sample 4708 is so sandy that there is very little plasticity or dry strength, trials cracked during drying. There was much scum, shades of red fairly good. Only use would be to reduce the plasticity and shrinkage of other clays.
4709—S.W. 25-6-13w2. Three and a half miles west of Halbrite and in the Souris Valley. Sample 4709 is very much like the above sample 4708, it is too sandy and weak. All trials cracked during drying. The burned shades of red are greyish and are not so good as those of 4708.

4710—S.E. 26-5-13w2. This small outcrop is 2½ miles N.E. of Goodwater and on Roughbark creek. Sample 4710 is a coarse grained kaolinized sandy Whitemud. It was very short, low drying shrinkage, burned very open and of high absorption. Its chief interest is for the kaolin it contains provided the deposit is not in the form of an isolated block. The whole general area should be checked.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden 4711	6 ft.	Brown	20.5	.....	010	.....	14.0	.....
					04	.....	12.6	.....
					1	.....	10.1	.....
					5	.....	7.9	.....
					10	.....	4.4	.....
Overburden 4712 Sandy	20 ft. 10 ft.	Grey	21.0	.....	010	.....	16.8	Very light red
					04	.....	16.1	Med. red
					1	.....	12.9	Dark red
					5	.....	7.4	O'firing
Overburden 4713 Sandy Whitemud	20 ft. 12 + ft.	Greyish White	19.2	4.3	010	−0.5	17.0	Fairly white
					02	0.5	16.6	Fairly white
					5	0.8	15.7	Specky white
					10	0.8	14.3	Specky white
Overburden 4714 Shale (Estevan)	Little 15 + ft.	Dark	25.1	.....	010	.....	13.4	L. brick red
					04	.....	12.0	Med. brick red
					02	.....	7.8	Dark brick red
					3	.....	2.9	Brown-red
					5	.....	.....	O'fired
Overburden 4715 Shale (Estevan)	0 + ft. 5 ft.	Dark	32.3	10.6	010	.....	11.1	L. brick red
					07	3.9	10.1	L. brick red
					04	8.7	0.0	Med. red
					02	.....	.....	Bloated

4711—S.E. 26-5-13w2. About one quarter mile S.E. of deposit 4710. Sample 4711 is the same type of clay as 4661 but it is not so plastic. All trials cracked during burning, hence colour and a rough check on absorption were the only properties obtainable from the burned trials. This clay is of the general stoneware type though should be made more plastic. Its uses then would be the same as 4661. They are among the clays of most interest in the general area, and are worthy of further investigations.

4712—N.W. 24-5-13w2. About three quarters of a mile down stream from the last sample. Sample 4712 is very sandy and short, it cracked while drying. It is undoubtedly from the same bed or horizon as samples 4708 and 4709. See notes regarding them.

4713—S.W. 13-6-13w2. About three miles west then one and three quarter miles south and on the west side of Souris River. Sample 4713 other than being a little less specky at the higher temperatures this clay is the same as 4710, see notes on that sample. The kaolin yield for this sample was 33%, the reflectance value, 56, was low for paper clay.

4714—S.W. 18-6-12w2. Down stream about one half mile from last sample and on the east side of the river. Sample 4714 is highly plastic and sticky, it cracked very badly during drying such that little data could be obtained. It is very much like sample 4703 as to burned colour range. By a pre-drying or chemical treatment these two clays might possibly be used for red face brick and tile.

4715—S.E. 17-6-12w2. About 2 miles S.W. of Halbrite and on the west side of a small stream. Sample 4715 is a fine grained highly plastic clay of good working properties. The drying shrinkage is a little too high, it scums badly and bloats at cone 02 up It is the same type clay as 4702, see it for use.

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden 4716 Sandy Whitemud	20 ft. 4 ft.	Light	23.3	6.2	010	.....	18.9	Pinky cream
					04	0.6	18.6	L. cream
					3	1.0	16.3	L. cream
					10	2.8	15.2	L. cream specks
Overburden 4717 Sandy (Estevan)	0–40 ft. 6+ ft.	Grey	15.3	0.8	010	.....	15.4	Pinkish buff
					04	−0.5	15.1	Lighter shade
					3	−0.1	12.7	Grey, blistered
					9	2.1	11.0	Grey, blistered
Overburden 4718 Shale (Estevan)	10 ft.	Grey	26.0	.....	.....	.....	.....	.....
Overburden 4719 Shale (Estevan)	Little 6 ft.	Rusty grey	26.5	.....	.....	.....	.....	.....
Overburden 4720 Sandy Whitemud	Little 7 ft.		21.0	4.8	010	.....	.....	Pink
					02	.....	.....	Nearly white
					5	.....	.....	Nearly white
					7	.....	.....	Nearly white
					10	.....	.....	Nearly white, specks

4716—N.E. 8-6-12w2. Located about one half mile down the valley from last sample and on the east side of the small stream. Sample 4716 other than being a little more refractory is the counterpart of sample 4704. Its interest is for its kaolin yield and to use with more plastic clays though care should be taken to make sure that the deposit is of any extent.
4717—S.W. 19-5-12w2. About one and one half miles N.E. of the C.N. Rly. trestle over Jewel Creek, east of Goodwater. Sample 4717 is a very sandy clay, is lacking in plasticity and cannot be used along, its burned shades are weak and it blisters from cone 3 up. Only use would be to reduce shrinkage. It is no doubt in the same bed as 4648 near the brick plant at Estevan.

4718—W.½. 11-7-13w2. South of Ralph near the abandoned auxiliary airport. Sample 4718 was very plastic and cracked within a few minutes after moulding. It is of no further interest as a clay products material.

4719—N.W. 2-7-13w2. Just east of turn in trail and 50 feet north of same where it rises over a small ridge. Sample 4719 reacted the same as last sample trials, cracked so badly impossible to obtain data. It is of no further interest.

4720—S.E. 25-6-13w2. About two and one half miles west and a half mile north of Halbrite. Sample 4720 is a kaolinized sandy Whitemud. The kaolin portions burn to a good white at all higher cones, it contains speck forming impurities. In case this same clay can be found in quantity it is worthy of washing and refining tests for its kaolin yield and uses.

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
4721	20 ft.	Light and Yellowish	17.8	3.4	010	.....	.....	Pink
					02	.....	.....	Pink-buff
					5	.....	.....	Buff
					7	.....	.....	Greyish-buff
					10	.....	.....	Bluestone & specks
Overburden 4722	0 – Heavy 20 ft.	White & Yellowish	.....	.....	.....	.....	.....	.....
Overburden	Very Little							
4723 Clay	5 ft.	Lead grey	25.4	7.3	010	.....	.....	L. cream
					02	.....	.....	Very light cream
					5	.....	.....	Nearly white
					9	.....	.....	Nearly white
					10	.....	.....	L .cream specks
4724 Sandy	8 ft.	Nearly white	.....	.....	.....	.....	.....	.....
Overburden 4725	Heavy 12 ft.	Light to Nearly white	.....	.....	.....	.....	.....	.....

4721—S.½. 17-6-22w3. Sample taken below No. 14 plastic stoneware clay at the pit south of Knollys. Sample 4721 must have included some low grade material other than the true Whitemud, is off shade when burned. As sampled it would be of very little interest other than in heavy wares like sewer pipe to reduce shrinkage.

4722—S. 27-6-23w3. Taken at an outcrop at the south edge of the clay pit at Ravenscrag butte, and from beds beneath the pit floor. Sample 4722 was taken for a test of its per cent. of kaolin and the fired properties of same. In that other deposits were of more interest this sample was not reached before the closing down of the laboratory work. From a rough examination the per cent. of kaolin appears to be low.

4723—N.W. 13-5-13w2. Across the valley north and a little east of the C.N. Rly. trestle over Jewel Creek east of Goodwater. Sample 4723 is a nearly white burning ball clay and is of further interest as to its quantity and uniformity. It is highly plastic and cracked during drying such that only the burned colours could be noted.

4724—S.E. 18-5-12w2. Taken from south bank of old creek bed where loop was cut off by C.N. Rly. Sample 4724 like 4722 was taken for a washing test and kaolin recovery, but time did not permit of its testing, trials were not made for burning. The deposit is badly disturbed.

4725—W.½. 12-6-28w2. Taken about 300 yds. south of the clay mine entry. Sample 4725 was taken as a sample of the kaolinized sandy clay below the ball clays outcropping in the valley near the mine entrance. The laboratory work did not reach this sample for a washing or burning test.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1947—Continued

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	None							
4726	10 ft.	White	22.5	5.9	010	−0.6	18.0	L. grey white
Sandy Whitemud					04	−0.6	16.8	L. grey white
					3	0.5	16.2	L. grey white
					9	0.8	15.7	L. grey white, specks
Overburden	Little							
4727	15 ft.	Greyish	26.9	8.8	010	−0.4	17.5	Deep cream
Sandy Whitemud					04	−0.1	17.1	Little lighter
					3	0.0	16.3	Same
					9	0.0	14.1	L. grey white specks
Overburden	10+ ft.							
4728	4+ ft.	White	25.0	7.0	010	−0.5	21.0	L. cream
Sandy Whitemud					04	0.3	19.9	L. cream
					3	0.7	17.7	L. cream
					10	2.1	15.7	L. cream Few specks
Overburden	10–35 ft.							
4734	1 ft.	Dark	28.8	10.5	010	.....	14.0	Deep cream
Clay					02	.....	10.6	Little lighter
					3	.....	8.1	Same
					7	.....	5.6	Same
					10	.....	2.7	Deep buff Badly specked and blue-stoned

4726—S.E. 5-5-4w3. South and east of Fir Mountain directly east across the Valley from the school house. Sample 4726 is a typical sample of the kaolinized sandy Whitemud for testing its kaolin yield. It appears to be fairly high in same, does not darken at cone 10 other than for specks. These trials show much yellow-green stain with vanadium.

4727—N.W. 5-5-4w3. On east side of creek north east of the above school house. Sample 4727 is a further sample of kaolinized sandy Whitemud, but not so pure as the last sample. It is a little more plastic and works better, dries safely. It burns off shade for a good white and becomes a little greyish at the higher cones. Not of much interest for washing for the kaolin. Best use would be in sewer pipe and structural ware bodies.

4728—N.E. 1-5-5w3. South of Fir Mountain near a dam and across the road from 4616. Sample 4728 is a fine grained kaolinized sandy Whitemud, it has some plasticity, low burning shrinkage and high absorption. The burned shades indicate its interest as a clay to be washed for the kaolin. Naturally it contains some speck forming impurities and is stained yellow-green quite badly. Becomes steel hard at cone 04.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1947—Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
4733 Clay	10 ft.	Chocolate	25.6	7.4	010	3.0	17.2	Very L. cream
					02	3.5	15.2	Lighter
					3	4.8	12.7	Same
					7	6.9	8.0	Shade darker
					10	8.3	6.0	Med. cream Many specks
4732 Clay	2 ft.	L. grey	34.4	8.5	07	.....	25.2	White
					02	.....	23.0	White
					3	.....	20.5	White
					7	.....	15.1	White
					10	.....	11.6	White
Lignite								
4731 Clay	3 ft.	Chocolate greyish	25.8	7.4	010	1.8	14.4	L. cream
					04	2.8	13.1	L. cream
					3	3.7	10.7	L. cream
					7	4.9	7.7	Deeper
					10	6.1	5.3	L. blue-stone
4730 Sandy	2½ ft.	Whitish	26.0	7.4	010	−0.6	19.6	Very L. cream
					04	−0.3	19.3	Nearly white
					3	1.0	18.2	Nearly white
					9	1.5	16.1	Nearly white Some specks
4729 Sandy	4 ft.	Brown	31.5	9.7	010	0.9	18.4	Very L. cream
					04	1.7	16.0	Lighter
					3	3.2	13.0	Same
					9	4.8	9.7	L. cream Few specks
Lignite The above beds are all of the White-mud and were first sampled in 1927.								

4729–4730–4731–4732–4733–4734—N.E. 27-5-3w3. South of Flintoft along the road to Wood Mountain. Sample 4729 is the lowest bed of the deposit, it is a fine grained sandy clay of the Whitemud. It has good properties as to drying and burning safely. It is quite free of specks. For whiteware use would require washing, is too absorbent for structural wares, might be of interest for some lower grade refractories. There is some yellow-green scum. Sample 4730 is less plastic than 4729 but could be moulded, has lower shrinkages and higher absorptions. The clay portion does not darken at cone 10. If washed, might be of interest in whiteware. Sample 4731 is a plastic clay of the ball clay type, it is not excessively plastic as are most ball clays, it dried and burned safely and was very light in shade up to cones 9 and 10 where some light bluestone grey developed. There were a few specks, but no stain. Was steel hard at cone 07. It has good possibilities for use in certain white-wares. Sample 4732 is a white burning ball clay but its rate of vitrification is not all that could be desired, though for high temperature wares it should prove of interest as one of the body ingredients. Sample 4733 is a ball clay which burns to a lower degree of whiteness than that of clay 4732 immediately below it in the deposit. It is however very light burning, but at cone 10 it develops many specks, these would not be permissible in

whiteware. In view of the thickness of the bed the clay is worthy of further attention and study of the removal of the impurities. Sample 4734 was very plastic and had to be carefully dried to prevent cracking. It cracked very badly during burning, the burned shades are poor and the clay is badly contaminated with impurities, both scum and speck forming. It is of little interest for use.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1947—Continued

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	20 ft.							
4736 Clay	10 ft.	Dark	28.0	9.1	010	.....	.....	Very light
					02	.....	.....	Very light
					3	.....	.....	Same
					7	.....	.....	Little darker
					10	.....	.....	Med. cream Large specks
4735 Sandy Whitemud	3 ft.	Light	27.9	8.0	010	0.6	18.6	L. cream
					02	0.8	16.8	Little lighter
					5	3.6	13.5	Same
					10	3.9	11.5	Same Fine specks
Lignite								
Overburden	20 ft.							
4737 Sandy Whitemud	7 ft.	White	20.5	5.4	010	−1.1	15.0	Greyish white
					02	−0.9	14.5	Greyish white
					5	−0.6	12.8	Greyish white
					10	−0.4	11.0	Greyish white Fine specks

4735–4736—S.E. 34-5-3w3. On the south side of the coulee just north of the section line. Sample 4735 is a very fine grained sandy light burning clay. It has good plasticity dries safely and burns without checking. The shades are good, it has some yellow-green stain and many very fine specks. Other uses than as a ball clay should be investigated. Sample 4736 is a fine grained ball clay which developed fire or cooling checks such that its burned properties could not be obtained. Other than the cracking it is practically the same clay as 4733 and is no doubt an extension of that bed. See notes on that sample for this one.

4737—N.E. 27-5-3w3. and S.E. 34-5-3w3. A prominent white outcrop, S.W. of Flintoft. Sample 4737 is a fine grained kaolinized sandy Whitemud clay. It has low plasticity, cannot be used alone. General use as a leaning agent, or to be washed for its kaolin portion which raw and burned offers promise of being white for use in paper or whitewares. The present burned trials show yellow-green stain.

4738–4739–4740—S.E. 34–5–3w3. Near fence line south of 4737. Sample 4738 is quite fine grained, highly plastic but did not crack during drying. It developed a yellow-green scum when burned. Otherwise it burns to a fairly good white. Its vitrification rate is gradual and continuous at least up to cone 10. It is a ball clay of promise.

Sample 4739 is not so plastic as last sample, and has a lower total shrinkage. It has some very fine grained silica present. It vitrifies very slowly as a ball clay. There is considerable vanadium scum present and numerous very fine speck forming impurities. It should be of more interest in some refractory bodies than for whiteware as a kaolin. Sample 4740 is a ball clay of a general average type for the district. It did not crack either during drying or burning. While there is considerable greenish scum or stain, the burned shades are good other than at cone 10 where it becomes too dark. The depth of the bed makes it important.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1947—Continued

Sample No.	Thick-ness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorp-tion	Burned Colour
Overburden	10 ft.							
Bentonite	3 ft.	Greenish						
Lignitic	1½ ft.	Dark						
4740	6 ft.	Dark	28.9	10.8	010	1.6	14.8	L. cream
Clay					02	2.3	10.9	Same
					5	4.0	8.2	Med. cream
					10	5.3	6.9	Deep cream Very few specks
4739	3 ft.	White	29.7	8.4	010	0.4	18.6	L. cream
Sandy					1	1.2	15.6	Little lighter
					5	1.3	14.9	Same
					10	2.2	11.7	Slight buff Very fine specks
Lignite								
4738	6 ft.	Chocolate	32.1	9.8	010	−0.1	14.0	Very light
Whitemud					02	1.8	12.2	Same
					5	3.1	9.9	Same
					10	5.4	6.9	Very light cream, few small specks
Overburden	40 – ft.							
4741	6 ft.	Light	30.5	9.5	010	0.1	17.6	Very light cream
Whitemud					02	0.3	15.6	Very light cream
					5	2.3	12.7	Very light cream
					10	5.2	9.9	Med. cream Fine yellowish specks

4741—N.½. 34-5-3w3. Located at first outcrop north of the quarter section line. Sample 4741 while a ball clay, is not quite so plastic as sample 4740 and its vitrification is slower and requires higher temperatures. It burns to a range of very good light shades other than some yellow-green scum. Its thickness of bed justifies further investigation.

4742—N.½. 34-5-3w3. First outcrop north of 4741. Sample 4742 not received at the laboratory.

4743—S.W. 20-5-2w2. Directly across from old farm buildings. Sample 4743 is medium sandy Whitemud clay of the kaolinized type which would prove of interest as a source of kaolin for whiteware in that the bed is of good depth and the clay portion does not darken at the higher temperatures.

4744—N.E. 16-5-3w3. On farm of Geo. Caragata, 300 yds. north of railway and at creek below buildings. Sample 4744 is a coarser grained kaolinized sandy clay than 4743. It is less plastic and is slightly more refractory. Its burned shade is darker than that sample and does not appear to be as promising for use in whitewares when washed. The specks are very fine and it might be difficult to remove them as impurities.

4745—N.E. 19-5-3w3. Near the farm buildings on the Okrancy quarter. Sample 4745 reacts in all respects like 4744 and needs no further comments other than it develops yellow-green scum. It is no doubt an extension of the same bed as that represented by 4744 of which a greater thickness was exposed and sampled.

4746—N.E. 25-5-4w3. South of Tunbridge Wells school, near the line fence. Sample 4746 was not tested for use as clay but was washed and elutriated giving a yield of 17.5% in tank 3 and 12.8% in the last or final tank. These two represent a 30.3% yield of kaolin.

REPORT OF PRELIMINARY CLAY SAMPLES COLLECTED DURING 1947—Continued

Sample No.	Thickness	Raw Colour	Per cent. Water Plast'y	Per cent. Dry sh'kge	Burned at cone	Per cent. Burned sh'kge	Per cent. Absorption	Burned Colour
Overburden	up to 35 ft.							
4742 Clay	6 ft.	Light						
Sandy white	3 ft.							
Overburden	Light							
4743	20 ft.	Light	24.4	7.0	010	−0.1	16.6	Chalky white
Sandy Whitemud					02	0.7	15.7	Same
					5	2.5	14.2	Same
					10	2.5	12.2	Greyish white, specks
Overburden	Very Little							
4744	10 ft.		18.9	4.6	010	−0.9	17.7	L. cream
Sandy Whitemud					1	−0.7	17.1	Greyish
					5	−0.6	16.9	Greyish
					9	−0.3	15.8	Greyish
					10	.....	.....	Greyish specks
Overburden	4 ft.							
4745	4 ft.	Light	18.8	5.5	010	−1.3	16.9	L. cream
Sandy Whitemud					1	−0.4	16.0	Greyish cream
					5	−1.3	15.7	Greyish cream
					10	−0.7	14.1	Little darker Specks
Overburden	Little							
4746	8–10 ft.	Light	.....	.....	.....	.....	.....	.....
Sandy Whitemud								

NOTE:—The balance of the samples to and including 4778 were taken from deposits of the kaolinized sandy Whitemud beds for a measure of their kaolin yields plus the raw and burned colour of each as obtained following their recovery by elutriation. The information obtained is given in the following tables. The work was completed in part only and for that reason much remains to be learned regarding the ultimate properties and uses of these kaolins.

UN-WASHED KAOLINIZED SAMPLES

Sample No.	Thickness of Bed.	Raw Colour	Location	†Approximate Colour Grade	Relative size of speck forming impurities	General Remarks
4747	6 feet	Not stated	S25-5-4w3	one	fine	This sample is nearly white when burned and takes first place of all following samples.
4748	15 feet	Dark grey	S½17-6-22w3	two	medium large	The kaolin from this clay might be useful in c.c. or other like wares.
4749	20 feet	Greyish	S½17-6-22w3	four	small	There is little promise of this clay being worthy of refining for pottery.
4750	15 feet	Not stated	S½17-6-22w3	four	small	There is little promise of this clay being worthy of refining for pottery.
4751	12 feet	Some Iron stain	S½17-6-22w3	five	fine	Of no further interest for whiteware.
4752	27 feet		S½17-6-22w3	four	small	Same as 4750.
4753	18 feet	Yellowish	S½17-6-22w3	five	fine	Same as 4751.
4754	24 feet	Not stated	S½17-6-22w3	two	fine	Is very much like 4748 but would prove more difficult to purify.
4755	6 feet	Not stated	S½17-6-22w3	one	medium to large	This bed is at the top of the outcrop, it is one of the few very light burning clays of the district.
4756	12 feet	Not stated	S½17-6-22w3	one	medium to large	This is undoubtedly a continuation of bed 4754. They are worthy of further attention.
4757	15 feet	Not stated	S½17-6-22w3	two	medium to large	Is the counter part of clay 4748 but should prove more easily refined.
4758	65 feet	Mostly light	S½17-6-22w3	one	large	This clay is one of the very few lighter burning samples of the district, like 4755.
4759	60 feet	Some	S½17-6-22w3	one	large	Same as above.
4760	16 feet	Not stated	S½17-6-22w3	four	small	Same as 4750.
4761	25 feet	Yellowish	S½17-6-22w3	four	medium large	See note re 4749.
4762	10 feet	Light	S½17-6-22w3	two	medium large	See note re 4748.
4763	12 feet	Greyish	S½17-6-22w3	five	medium large	See note re 4751.
4764	15 feet	Not stated	S½17-6-22w3	three	large	Of little interest for pottery. Too dark for whiteware.
4765	7 feet	Not stated	S½17-6-22w3	three	large	As above.
4766	10 feet	Not stated	S½17-6-22w3	two	large	Refining should not be difficult. See notes re 4748.
4767	15 feet	Not stated	S½17-6-22w3	three	large	Same as 4764.
4768	3+ feet	Not stated	SW.16-6-22w3	three	large	Same as 4764.
4769	25 feet	Light	SE.16-6-22w3	five	large	See note re 4751.

4770	15 feet	Not stated	SE.29-6-22w3	one	fine	This is a promising sample from the north side of the Frenchman Valley at Knollys.
4771	7 feet	Not stated	S.29-6-22w3	two	medium	See note re 4748.
4772	From a blasted hole	Not stated	S½17-5-22w3	two	large	As above. Should refine more easily than 4748.
4773	From a blasted hole	Not stated	S½17-5-22w3	one	large	This bed should be checked in that it corresponds closely to 4754 and 4755.
4774	From a blasted hole	Not stated	S½17-5-22w3	four	large	Too dark for whiteware.
4775	10 feet	Greyish	SE.26-6-22w3	five	fine	Too dark for whiteware.
4776	From a blasted hole	Not stated	S½17-5-22w3	five	medium	Too dark for whiteware.
4777	6 feet	Discoloured	S.13-6-23w3	two	fine	Not quite so favourable for refining as 4748, is of same shade
4778	From an auger hole	Not stated	On highway No. 13, about 3 miles SW. from Eastend	sample	missing	

†—Grade One—Best Whites
Grade Two—Light Cream
Grade Three—Med. Cream.
Grade Four—Cream.
Grade Five—Greyish dark cream.

The above comments are based on the unwashed samples burned oxidizing at cone 12. The information is of value in selecting for further study those samples of most promise as to whiteness and their feasibility of refining treatment.

APPENDIX B

TEMPERATURE EQUIVALENTS OF ORTON PYROMETRIC CONES.

Cone No.	End point, 20° C. per hr.		End point, 150° C. per hr.	
	°C.	°F.	°C.	°F.
022	585	1090	605	1120
021	595	1100	615	1140
020	625	1160	650	1200
019	630	1170	660	1220
018	670	1240	720	1330
017	720	1330	770	1420
016	735	1360	795	1460
015	770	1420	805	1480
014	795	1460	830	1530
013	825	1520	860	1580
012	840	1540	875	1610
011	875	1610	895	1640
010	890	1630	905	1660
09	930	1710	930	1710
08	945	1730	950	1740
07	975	1790	990	1810
06	1005	1840	1015	1860
05	1030	1890	1040	1900
04	1050	1920	1060	1940
03	1080	1980	1115	2040
02	1095	2000	1125	2060
01	1110	2030	1145	2090
1	1125	2060	1160	2120
2	1135	2080	1165	2130
3	1145	2090	1170	2140
4	1165	2130	1190	2170
5	1180	2160	1205	2200
6	1190	2170	1230	2250
7	1210	2210	1250	2280
8	1225	2240	1260	2300
9	1250	2280	1285	2350
10	1260	2300	1305	2380
11	1285	2350	1325	2420
12	1310	2390	1335	2440
13	1350	2460	1350	2460
14	1390	2530	1400	2550
15	1410	2570	1435	2620
16	1450	2640	1465	2670
17	1465	2670	1475	2690
18	1485	2710	1490	2710
19	1515	2760	1520	2770
20	1520	2770	1530	2790
23	.....	.....	1580	2880
26	.....	.....	1595	2900
27	.....	.....	1605	2920
28	.....	.....	1615	2940
29	.....	.....	1640	2980
30	.....	.....	1650	3000
31	.....	.....	1680	3060
32	.....	.....	1700	3090

APPENDIX B

TEMPERATURE EQUIVALENTS OF ORTON PYROMETRIC CONES—Continued

Cone No.	End point, 20° C. per hr.		End point, 150° C. per hr.	
	°C.	°F.	°C.	°F.
33	.....	.....	1745	3170
34	1755	3190	1760	3200
35	1775	3230	1785	3250
36	1810	3290	1810	3290
37	1830	3330	1820	3310
38	1850	3360	1835	3340
39	1865	3390	.....	.....
40	1885	3430	.....	.....
41	1970	3580	.....	.....
42	2015	3660	.....	.....

Note:- Cones 23 to 38 heated at 100° C. per hr.

INDEX

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