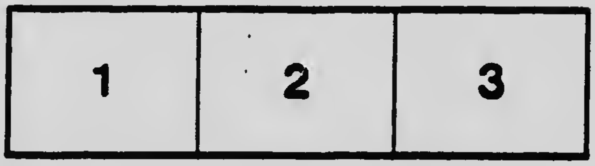
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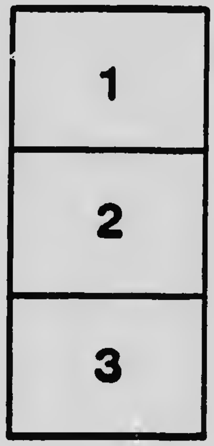
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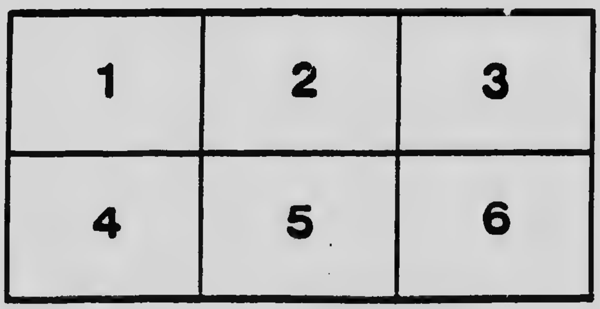
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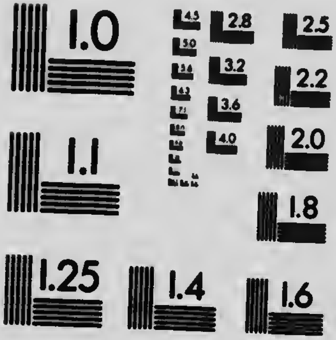

Dr. Robt. Bell

CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

Hon. W. Templeman, Minister; A. P. Low, Deputy Minister;
R. W. Brock, Director.

MEMOIR No. 16–E

THE CLAY AND SHALE DEPOSITS

OF

NOVA SCOTIA AND PORTIONS OF NEW BRUNSWICK

BY

HEINRICH RIES

ASSISTED BY

JOSEPH KEELE

OTTAWA
GOVERNMENT PRINTING BUREAU
1911

No. 1118

HON W TE

LEGEND

+ Pleistocene

● Shales

○ Fire clays and stoneware clays

Canada

Department of Mines

GEOLOGICAL SURVEY

HON W TEMPLEMAN MINISTER A P LOW DEPUTY MINISTER
R W BROCK, DIRECTOR

1911

C.O. Senécal, *Geographer and Chief Draughtsman.*
A. Dickison, *Draughtsman.*

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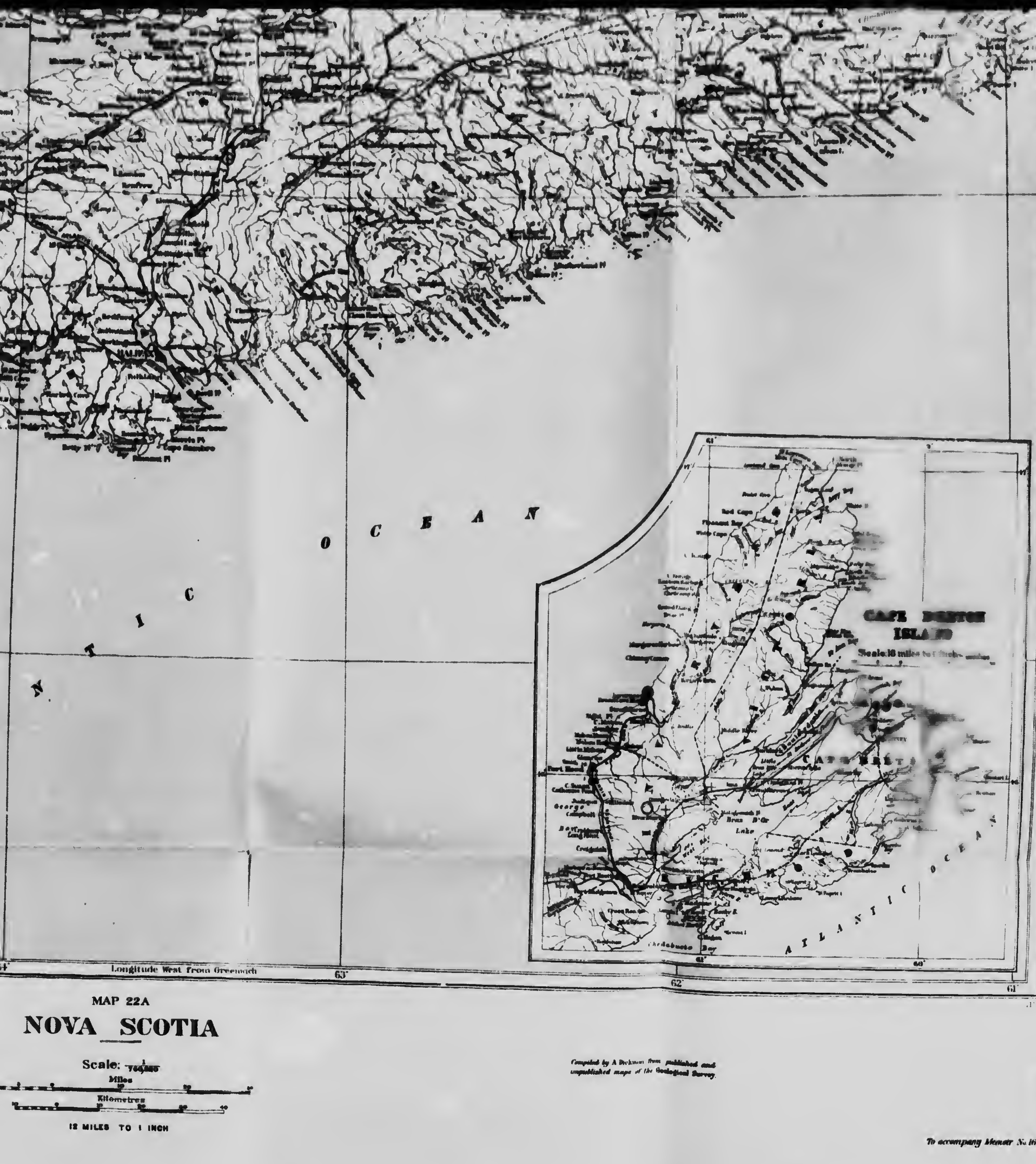

MAP 22A

NOVA SCOTIA

Scale: $\frac{1}{760,320}$

Miles

Kilometres

12 MILES TO 1 INCH

Compiled by A. Dickson from published and unpublished maps of the Geological Survey.

To accompany Memoir No. 16

CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

HON. W. TEMPLEMAN, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

MEMOIR No. 16–E

THE CLAY AND SHALE DEPOSITS

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ASSISTED BY

JOSEPH KEELE

OTTAWA
GOVERNMENT PRINTING BUREAU
1911

No. 1113

To R. W. Brock, Esq.,
Director Geological Survey,
Department of Mines,
Ottawa.

Sir,—I beg to submit, herewith, a report on the Clay and Shale Deposits of Nova Scotia and a portion of New Brunswick.

I have the honour to be,
Sir,
Your obedient servant.

(Signed) **Heinrich Ries.**

September 20, 1910.

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PART II.

ILLUSTRATIONS.

Photographs.

THE CLAY AND SHALE DEPOSITS

OF

NOVA SCOTIA AND PORTIONS OF NEW BRUNSWICK,

BY

HEINRICH RIES,

ASSISTED BY

Joseph Keele.

INTRODUCTORY.

The following report on the clay and shale deposits of the Maritime Provinces embraces the results of field work carried on during the summer of 1909; and laboratory tests made during the following winter. The writer was assisted in the field by Mr. Joseph Keele, and in the laboratory by Mr. E. K. Soper, and in part by Mr. Keele.

The object of the investigation was to ascertain, as far as possible, which of the geological formations in the area referred to contained clays or shales of economic value, and, consequently, special attention was given to those that appeared to be promising. In our field work we were guided to a large extent by the geologic maps prepared with such care by the late Mr. Hugh Fletcher.

Certain areas were examined by Mr. Keele alone, and the descriptions of these are credited to him.

As it is difficult to tell much about the qualities of a clay from its appearance in the field, samples for laboratory tests were taken from a number of localities. These samples were generally of about 50 pounds weight, and were taken usually by trenching the bed from top to bottom, throwing out or excluding only such impurities or layers as it would be practicable to remove in working.

In the laboratory the samples were put through a jaw crusher, the crushed material mixed with the necessary amount of water, and moulded into bricklets 4″ × 2″ × 1½″.

These bricklets were, after air drying, burned to cone 010 in an oil kiln, in 10 hours. The other burns were made in a gas-fired kiln. The shrinkage, colour, hardness, and absorption of the bricklets were measured after burning to each cone.

Many of the samples were burned at successively higher temperatures until they fused, but others of less importance were fired at only one or two cones.

A separate lot of clay was mixed up for making the briquettes.

In describing the results of the work it seems best to take up the discussion of the clays by formations, treating the several provinces separately.

The clay-working industry, and the tests made on the bricks, are given in separate chapters.

PART I.

THE CLAY DEPOSITS AND CLAY INDUSTRY.

NOVA SCOTIA.

CHAPTER I.

The geological formations of Nova Scotia range from the Pre-Cambrian to the Triassic, and are nearly everywhere overlain by a mantle of Pleistocene material of variable thickness. In certain formations the character of the material is such that there is little probability of its being of any value to the clay worker; others, however, contain a large number of argillaceous beds.

Those geologic formations of little or no value are referred to first, while the details of the more promising ones are discussed next.

Formations of no Great Value to the Clay Worker.

PRE-CAMBRIAN.

The Pre-Cambrian, which includes crystalline rocks of either igneous or metamorphic character, underlies a large portion of southwestern and southern Nova Scotia proper, as well as extensive areas in northern Cape Breton and scattered tracts in the southeastern portion of it.

None of the Pre-Cambrian rocks are of plastic character, nor do they become plastic when finely ground, and while they have no doubt weathered down to residual clays in the past, these have been largely removed by glacial action.

The only deposit of residual material known to the writer is a small pocket on Coxheath mountain, near Sydney, the clay there having been formed by the decomposition of a light coloured felsite, rather common in that region. This deposit is too small to be of any economic value, but nevertheless it has served to attract attention to the locality, and in recent years numerous rumors have been circulated regarding the availability of the felsite for firebrick manufacture.

In view of these facts the locality was examined with some care.

Coxheath Mountain.—Coxheath mountain lies in a southwesterly direction from the city of Sydney. It is surrounded by lower Carboniferous shales and conglomerates, and these also rest on its lower slopes, and form the flanks of an anticline, of which the mountain is the central portion.

The summit and main part of the mountain is composed largely of Pre-Cambrian felsite, cut in places by basic intrusions. Metamorphism has induced a schistosity in some parts, at least, of the felsite.

Two kinds of felsite were noticed, the one a yellowish white type, and the other deep red. The former has a composition somewhat resembling that of a siliceous fireclay, and it is probable that its decay would yield a kaolin, or whitish residual clay, of fairly refractory character. It is inconceivable how—if any did form in the past—much of it could have remained, because of the glaciation to which the ridge has been subjected.

There is in the Provincial Museum at Halifax, a specimen of white residual clay, said to have come from Coxheath mountain, and collected a number of years ago. Inquiry, and a search of certain private records placed at our disposal, showed that a small pocket of clay was found in a depression on the top of the ridge, about half a mile beyond John McMillin's house. It may be a patch that has escaped glacial erosion, or it may possibly be of post-glacial origin, although the former is more likely. There is not enough in any case to be of economic value.

But there is an unlimited quantity of the light-coloured felsite, and this material is locally called fireclay, and the statement often made that firebrick ca.. ,e and have been manufactured from it alone. A small amount has been quarried in the woods on the John McMillin property, and piled up by the opening. (See Plate I.)

This material is a fine-grained, much sheared felsite, often having a somewhat talcose appearance, and in places traversed by numerous small quartz veins, which appear to occupy torsion cracks. At the eastern end of the quarry the felsite is in contact with a darker coloured sheared porphyry. (Fig. 2.)

In order to thoroughly test the possibilities of this rock, a sample of it was collected from the pile at the quarry and broken down in the crusher.

As using the felsite alone, without a bond, is out of the question, three sets of mixtures were made up as follows:—

PLATE I

Quarry in Felsite, Coxheath mountain, Cape Breton.

8907—p. 14

I. Felsite 75 per cent. and 25 per cent clay from Hussey drift at Inverness.

II. Felsite 50 per cent. and 50 per cent Hussey clay.

III. Felsite 50 per cent. and Shubenacadie fireclay 50 per cent.

The percentage of plastic clay used was greater than necessary, and it is probable that 10 per cent would suffice.

FIG. 2.—Section of felsite deposit at quarry, Coxheath mountain, C.B.

The properties of the several mixtures above mentioned were as follows:—

I. Water required, 16·6 per cent. and resulting mixture quite plastic. Air shrinkage, 5 per cent. Cone 010, fire shrinkage, 1·6 per cent. Cone 5, fire shrinkage, 0 per cent; absorption, 9·22 per cent. Cone 9, fire shrinkage, 0 per cent; absorption, 5·45 per cent. The bricklets were solid and steel hard at cone 5.

II. Water required, 17 per cent. Air shrinkage, 5·6 per cent. Cone 010, fire shrinkage, 0·6 per cent. Cone 5, fire shrinkage, 2·3 per cent; absorption, 6·81 per cent. Cone 9, fire shrinkage, 3·3 per cent; absorption, 3·35 per cent. The clay burns steel hard at cone 5, and shows a tendency to form slight cracks around the angular felsite grains.

III. Water required, 19 per cent. Air shrinkage, 3·3 per cent. Cone 010, fire shrinkage, 1·3 per cent. Cone 5, fire shrinkage, 0·4 per

The bricklets were steel hard at cone 5.

It can thus be seen that the use of the felsite alone is out of the question; and the test bricks which were shown to the writer in Sydney contained a fireclay bond, by the use of which, as corroborated by our own experiments, it is possible to make a hard brick.

If the clay from the Hussey drift at Inverness were used as a binder it could be combined with the felsite found in the mountains northeast of the town, instead of shipping it to Sydney.

SILURIAN.

The rocks of this system underlie a narrow area on the south side of the Annapolis valley, and irregular areas in the eastern half of Pictou and northern half of Antigonish counties[1]. They are of economic importance because of the deposits of iron ore they contain. Associated with these are somewhat extensive deposits of shale, but the material is rather siliceous and slaty in its character, and of exceedingly doubtful value for the manufacture of burned clay wares.

Some of those associated with the Clinton ores near Arisaig were tested, but were found to be rather low in their plasticity, and also of low fire shrinkage, but good red colour when burned. Their only probable use would be for mixing with some of the shales from the Millstone Grit found along Bailey brook, in Pictou county. These are referred to on a subsequent page.

DEVONIAN.

The Devonian rocks underlie a narrow belt of irregular width extending through the central part of Nova Scotia; some small areas in southwestern Cape Breton to the northeast and southwest of St. Peter bay; and another on the northeastern side of the Straits of Canso, near Hastings.

The Devonian rocks were examined in these several areas, but were found to be either too schistose in their character, or, where of argillaceous nature, contained too much silica, present either as disseminated sand in the shale, or as interbedded sandstone layers. Were it not for the latter, the material, though siliceous, could no doubt in some cases be used for brick manufacture.

---

[1] Some of the latter may be Ordovician.

TRIASSIC.

The Triassic rocks underlie one belt that follows the Annapolis valley, and another one along the north shore of Cobequid bay, tapering out east of Truro. They are usually sandy in character, and, as far as has been determined, cannot be considered as a source of either clay or shale to be used in the manufacture of clay products.

Important Clay-Bearing Formations.

From what has been said in the preceding pages it will be noted that the formations likely to yield clay or shale deposits of value must be the lower Carboniferous, Millstone Grit, Coal Measures, Permian, and Pleistocene. These are few in number, but nevertheless they underlie areas of considerable extent.

LOWER CARBONIFEROUS.

Underlying, as it does, a rather extensive area in central Nova Scotia, and another one in Cape Breton, it is to be regretted that the lower Carboniferous has not been more widely investigated by clay-product manufacturers. The formation has strong possibilities, however, and should be carefully looked into, but it cannot be expected to yield plastic materials at all points, especially where it is composed largely of conglomerate. The so-called Carboniferous Limestone member is the most promising.

Many shales associated with the gypsum beds are quite plastic when ground and mixed with water, but in places these are also highly ferruginous, and often contain impurities, such as concretions of gypsum, etc. They could be used for brick manufacture, provided these impurities were eliminated by screening, or rendered more or less harmless by crushing.

The Carboniferous Limestone Series.—This is described by Fletcher as 'consisting of thick beds of red and grey argillaceous shale, sometimes calcareous, approaching in character to marls, and frequently without any traces of lamination or bedding; these beds being often copiously charged with nodules of limestone and argillaceous iron ore. With them are associated numerous beds of limestone, concretionary, laminated, and compact, and generally dark grey or almost black.' Beds of gypsum and sandstone may also be present.

Sydney Area.—The Carboniferous limestone formation underli the city of Sydney, and forms a narrow belt along the east side Sydney harbour almost to Liscomb point. A much broader an crescent-shaped area extends from the valley of Sydney river up t Point Edward, and southwestward up the valleys of Bull creek an Leitch creek, whence it sends a narrow extension up the valley o George creek to St. Andrews channel.

Outcrops are rather scarce, and where found they are apt to b limestones.

Shales, may, however, occur, and were found outcropping at a few points, one of the best exposures found being along the shore of the South Arm of Sydney harbour, just north of the Marine Hospital.

A sample of these shales was taken from near the Marine Hospital on Point Edward. This sample worked up with 18·6 per cent water to a coarse-grained but plastic mass, whose air shrinkage was 3·9 per cent.

It burns to a reddish brick, with 0·3 per cent fire shrinkage, and 10·78 per cent absorption at cone 010, but is puffed and blistered by cone 1. The material could be used for common brick, but some trouble would be caused in digging it, by the thin sandstone layers. They may, however, be less abundant in other parts of the formation.

Hawkesbury Area.—South of Hawkesbury, and north of Bear head there are a number of outcrops of sandstone with interbedded shales. Most of these are ferruginous and siliceous. Even if they were of proper quality, they are so intimately interbedded with the sandstones as to be of no value.

However, two small sacks were taken from one bed, just north of Bear head. The laboratory tests bore out the impression formed in the field, viz., that the shale is too hard and sandy to be of much value. It burns to a dark red colour, with a low fire shrinkage, and fuses at cone 1.

Pugwash.—The lower Carboniferous limestone formation underlies a small area on the southwest side and northeast side of the inner harbour at Pugwash; the two as indicated on the map, Fig. 3, being evidently parts of the same belt. Another small area of irregular oval form lies south of Pugwash river, about four miles south of the village of Pugwash (Fig. 3.)

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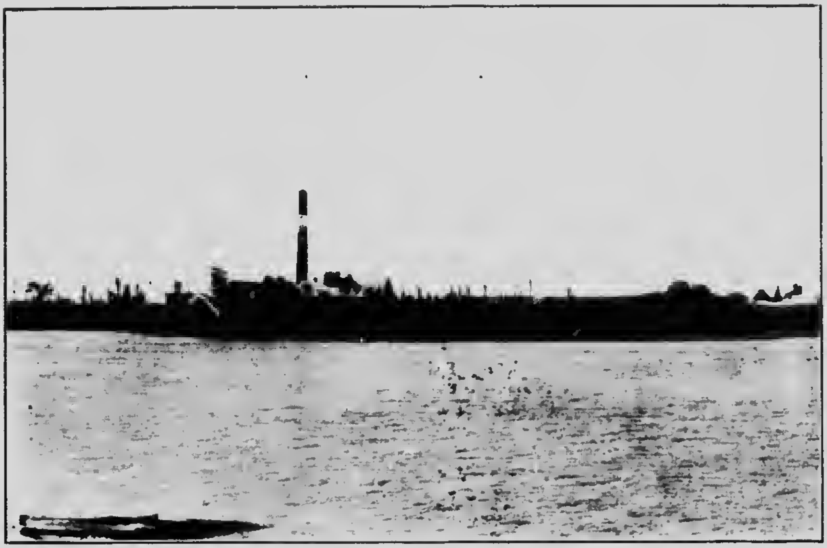


General view of Maritime Brick Works, Pugwash, Nova Scotia.

PLATE III.

Quarry of Maritime Brick Works, Pugwash, Nova Scotia. Top of bank.

PLATE IV.

Quarry of Maritime Brick Works, Pugwash, Nova Scotia. Base of bank.

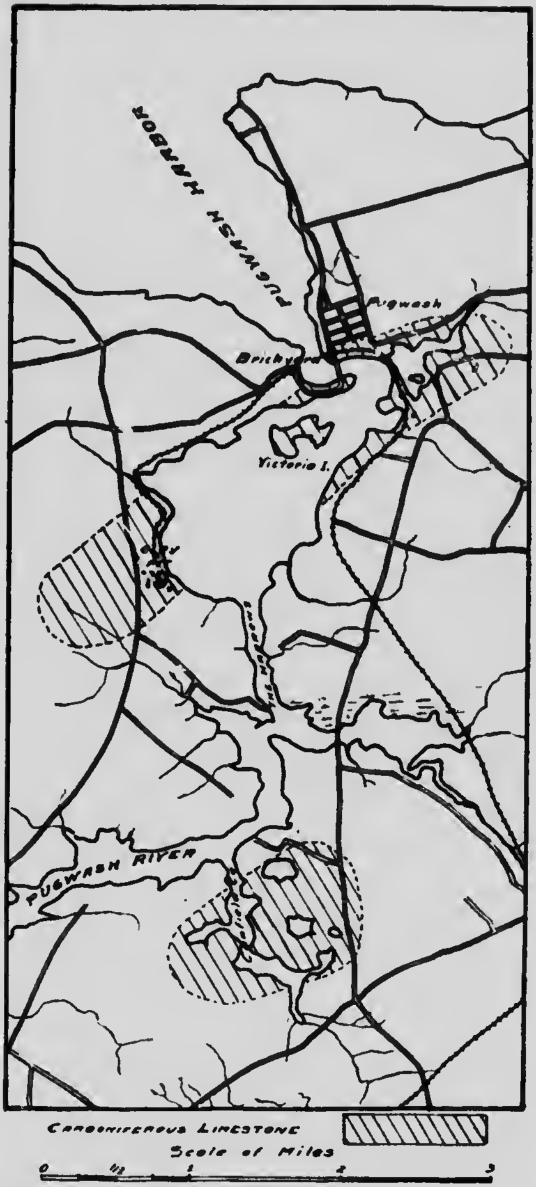


Fig. 3.—Map of Pugwash and vicinity.

In the first named of the three areas, as is sometimes the the shale is far more abundant than the limestone, but no de statement can be made regarding the other two, owing to the sc of outcrops.

It is in the area on the west side of the inner harbour t clay pit has been opened for obtaining brick material, and the acter of the product made is such as to warrant its trial at localities where the shale of this formation can be found. The crop at Pugwash forms a bank about 25 feet high, the upper 5 being a somewhat stony glacial clay, but under it is the st dipping mellowed shale, which seems to extend to a depth of 10 feet, below which it becomes somewhat harder.

About 500 feet west of the shore, a steeply dipping bed of stone has been worked for furnace flux, and the shale is said t tend back to this.

The only visible impurities in the shale are some streak selenite.

The following tests give the characters of a mixture of mellowed and nearly fresh shale, the sample being taken from stock pile at the factory.

The shale worked up with 22 per cent of water to a smooth tic mass, 67 per cent of which, when dry, passed through a 200 n sieve. Its air shrinkage was 6 per cent, and the average te strength 75 pounds per square inch. The firing tests were as belov

Cone.	Fire Shrinkage	Absorption.	Colour.
	%		
010	0·1	1[illegible]	Red.
05	3·6	8·31	Dark red.
03	7·3	2·95	Red brown.

This is a good brick clay, for it burns to a hard body, with fire shrinkage, good colour, and moderate absorption at 010. It comes steel hard, but of darker colour at 03.

A good dry-press bricklet, with 8·16 per cent absorption, and d red colour, was obtained at cone 03.

Shubenacadie[1].—Two miles west of Shubenacadie, grey plas shales occur on the property of Mr. John McDonald. The sh

[1] Examined by J. Keele.

weathers easily at the surface into a dirty yellowish plastic clay. The thickness of the shale bed is unknown, but it is at least 4 feet thick where exposed in the field near Mr. McDonald's house. The same shale is also seen on Ryans brook in this vicinity. The shale when worked up with 30·4 per cent of water was quite plastic, but rather gritty, the average air shrinkage being 8·6 per cent. In burning it behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.
	%	%
010	0·3	21·83
03	1·6	17·10

It burns to a fair colour, but is not steel hard at cone 03. Common brick could be made from it, but with the abundance of good surface clay which exists in this region it would hardly pay to work it.

MILLSTONE GRIT.

This formation is well exposed at a number of points, as follows: (1) in the area north of the Coal Measures in the Joggins district; (2) north of the area of outcrop of the Coal Measures in the Pictou coal field; (3) southeast of Hawkesbury; (4) near Wallace in Pictou county; (5) north of Antigonish; (6) west and southwest of the Sydney coal field.

Speaking in general terms, one cannot predict the universal distribution of promising clay or shale beds in the Millstone Grit, but small beds are not uncommon. Unfortunately, outcrops are scarce in many of the areas underlain by the rocks of this age, and this increases the difficulty of finding clay or shale beds in it.

North of Joggins, the Millstone Grit shows a continuous exposure in the cliffs along the Bay of Fundy shore; but the beds are mostly sandstones, with here and there a few thin shaly layers. Only one shale bed of importance was noted, and that was in the grindstone quarry about one mile north of the Joggins wharf. This bed is not more than 10 feet thick, nor is it well located for extensive working. If used, it would have to be opened as a long narrow cut.

In the Pictou coal region, some red-burning shales are found in the Millstone Grit, just north of the Intercolonial railway, and about half way between New Glasgow and Woodburn; but they a doubtful value, partly by reason of the uncertainty of their e. The overburden is, moreover, too thick to permit the clay worked as an open pit, and it is not of sufficiently high grad underground mining.

There are some exposures of a soft shale in the Millstone along the shore road just west of Wallace, but they do not ap to be of high grade, and their proximity to the highway and rounding houses would prevent their being worked. Red pl shales were found by Mr. Keele along the road crossing on B brook, Pictou county, within the area underlain by the Mill Grit. This bed comes to the surface, and is of sufficient thicl to form a workable deposit.

The following data show the results obtained on testing: (1) red shale of Millstone Grit from Bailey brook, Pictou county, (2) a mixture of 50 per cent No. 1612 and 50 per cent grey Silu shale from Arisaig:—

——	1.	2.
	%	%
Plasticity	Fair.	Low.
Air shrinkage	4·3	3·33
Cone 010—		
Fire shrinkage	2·6	0
Absorption	9·5	11·9
Colour	Red.	Red.
Cone 05—		
Fire shrinkage	5·3	0
Absorption	4·0	3·5
Colour	Red.	Dark red
Cone 1—		
Fire shrinkage	5·3	0·8
Absorption	0·2	1·8
Colour	Red brown.	Brown.

A similar bed of red shale, but containing sandy layers, is posed on the shore about half a mile beyond the mouth of Knoyd brook.

One drawback to the Bailey Brook material is that it lies too f from rail or water transportation. Yet it is probable that this sa shale may be found in a more favourable location, since the form tion extends northeastward to the shore, and southwestward to t line of the Intercolonial railway.

The Millstone Grit occupies a rather extensive area to the east of Sydney, and borders the Coal Measures on the west, southwest, and south, a strip projecting to the shore on the north side of Cow bay.

The beds are well exposed in the cliffs along: (1) the east side of Sydney harbour south of Victoria Mines P.O.; (2) on the west side of Sydney harbour, south of Stubbart point; (3) on both sides of St. Andrews channel from about Jessop and Grove points to the entrance of the Little Bras d'Or; and (4) on the north side of Cow bay.

Wherever exposed the formation consists usually of sandstone, with occasional beds of shale and coal. Aside from the exposures along the coast line outcrops are rather scarce.

Although scattered shale beds occur, the only one of importance is that seen in the Ashby pit, on the border of the city of Sydney.

Here, the Dominion Iron and Steel Company has made an opening to obtain clay for stopping the tap holes of the blast furnaces, taking their supply in part from surface clay, and in part from the weathered outcrop of a 12 foot layer of shale, underlying sandstone. The lower 4 feet of the shale bed are somewhat sandy.

This shale, when ground and passed through a 20 mesh sieve, was mixed with 22 per cent of water, giving a smooth and plastic mass. The air shrinkage was 9·2 per cent, and the tensile strength averaged 148·3 pounds per square inch. The firing tests were as follows:—

WET MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	1·2	11·24	Buff.
05	4·3	6·75	Dark buff.
03	5·0	6·40	"
1	5·0	3·83	"
3	0·3	3·43	"
5	2·3	4·16	
9	Swelled and blistered		

The conclusions regarding this sample are that it would make a good building brick at cone 010, but the colour is rather light. It gave a good colour and was steel hard at cone 05. On further heating it showed little change at 03. At cone 1, the colour is dark and the brick apparently vitrified, but it held its shape even to 3. It makes a fairly hard dry-press brick with good colour at 03, and could be used for pressed brick. The material is not a clay, as has been claimed by some, although it is one of the refractory found in the Sydney field, not excluding the Coal M ures shales and clays.

The exact extent of the bed is not known, as glacial drift co the outcrop, but a little ditching and boring would be require ascertain its probable continuation along the strike; although situation is such that for any considerable production it woul necessary to employ underground methods of working.

A similar clay is said to occur at the base of the hill behind coking plant of the Dominion Iron and Steel Company.

COAL MEASURES.

The Coal Measures represent the most important clay and sh bearing formations in Nova Scotia and deserve somewhat deta mention. They were also somewhat carefully examined because was hoped that they might contain fireclays. This hope was unf tunately strengthened at first by the numerous rumours of firec beds which we heard, but most of these arose from the custom ma coal miners have of referring to every clay under coal as a firecl This view is incorrect, as is also the view held by many that f clays always occur in close association with coal seams. Indeed, find a contradiction of this statement in the Shubenacadie distri where fireclay occurs, but no coal is found.

The areas in which the Coal Measures rocks are found includ (1) the Sydney area of northeastern Cape Breton; (2) Inverne area; (3) Port Hood area; (4) Mabou area; (5) Pictou county are (6) Maccan district; (7) Joggins area.

The most abundant exposures, and most extensive deposits the Coal Measures clays and shales, are found in the Sydney regio and may, therefore, be first mentioned.

Sydney Field.—In this district the shales and clays form an a most continuous series of outcrops from the Big Bras d'Or to Co bay, the only interruptions being at a few points where the land su face is low and covered by drift, and at Cape Percy on the north eastern shore of Cow bay, where the Millstone Grit extends to th shore line and cuts out the Coal Measures.

Owing to the almost uninterrupted line of cliffs along the shore a fine series of exposures was obtained.

By way of general explanation it may be remarked that the Sydney coal region is divided into several parts by deep northeast-southwest bays, and, consequently, it is somewhat difficult for geologists to correlate the sections in the several subdivisions of the field.

It may be stated, however, that the coal beds are interstratified with shales, sandstones, and some limestones, the whole series being bent into a number of gentle folds, forming the bottom of a broad trough dipping out under the sea. Cow bay, Glace bay, Sydney harbour, and the Bras d'Or mark the position of the synclinal basins. Low dips prevail throughout the region, thus giving fairly broad outcrops in many cases.

The coal seams appear to be fairly continuous, but the same cannot always be said of the shales or sandstones. This, consequently, minimizes the importance of any statement relating to the stratigraphic position of any given shale beds.

Towards tho northwestern and southeastern ends of tho field the sandstone beds predominate, and the shales are of poorer quality, being very gritty; but in the central portion representing the higher beds, the shales are as abundant as the sandstones.

The shales themselves range from fairly smooth, fine-grained, plastic shales of grey or red colour to others quite silicecus in their character, and of doubtful value. Although the aggregate thickness of the shale beds is high, few of the individual beds are very thick; indeed, there is frequently a rapid alternaticn of shales, sandstones, and sandy shales. As a result, many shales of good quality are not workable under local conditions, becauso of the abundance of sandstone layers which they contain.

The land area occupied by the productive Coal Measures amounts, according to Fletcher, to about 200 square miles.

The Coal Measures overlie the Millstone Grit, but are not always sharply differentiated from it.

The several parts of the coast line exposures may now be referred to in more detail, beginning at Sydney and following the coast to the Big Bras d'Or, and then from Sydney to Cow bay.

North Sydney to Big Bras d'Or.—From North Sydney to Indian cove (Fig. 4) there are low cliffs of sandstone, with few shales, belonging to the Millstone Grit. The Coal Measures, however, begin

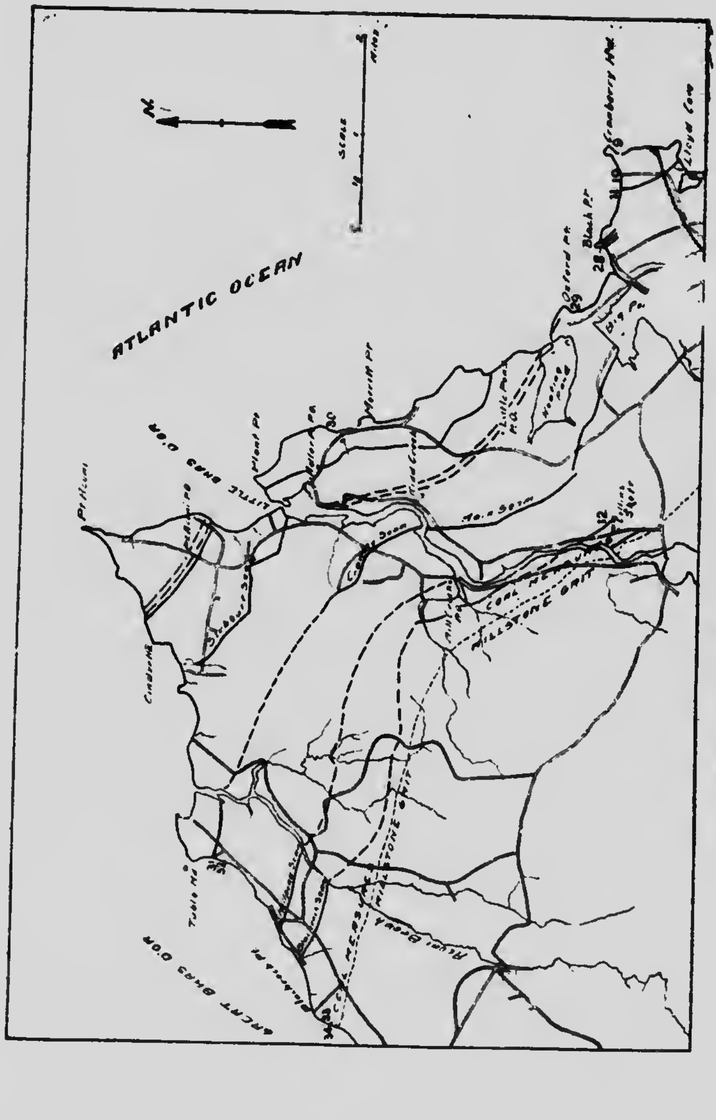


FIG. 4.—Map of Sydney coal field from Cranberry head to Gı d'Or.

PLATE V.

Cranberry head, near Sydney Mines, Cape Breton.

PLATE VI.

Coal Measures shales, Indian cove, Sydney harbour, Cape Breton.

about half a mile south of Indian cove; and about quarter of a mile south of this point there is a low northeasterly dipping bed of shale about 10 feet thick, which is overlain by sandstones, but which could be worked along the outcrop.

This shale is of somewhat gritty character, but worked up with 17·6 per cent of water to a fairly plastic material, whose air shrinkage was 4·3 per cent.

Cone.	Fire Shrinkage.	Absorption.
	%	%
010	0·7	13·42
03	5	5·84

The clay became steel hard at 03, and had a fair red colour, but it was much darker at cone 1, and would not stand much more than this. It could be used for common brick.

This is about 300 feet south of Stannart point, and shortly before reaching the first house on the shore south of Indian cove. Between this point and the dock nothing promising appears.

Just north of Indian cove there is a shale bed, similar to the Cranberry Head material, but it carries a heavy overburden of sandstone. (Plate VI).

From Indian cove to Cranberry head there is an almost unbroken line of high cliffs, containing many shale beds, but so interbedded with sandstones that they are not workable. Moreover, to work these would interfere with the surface operations of the coal company.

When Cranberry head, north of Sydney mines is reached, some good exposures appear.

Cranberry head is a point which projects into the sea from a point on the shore line, 1½ miles north of Sydney mines. The sides are quite steep, and the point is surrounded by water. On the south side one sees a good exposure of shale, which is not less than 20 feet thick and dips eastward, (Plate V), so that it passes under other beds forming the end of the point.

The bed is mostly a greyish, soft shale, containing small iron carbonate concretions in the upper 3 to 6 feet. Under this is a greyish shale, then a layer streaked with limonite and some thin films of coal. This shale, which is underlain by a harder one not less tha 15 to 20 feet in thickness, weathers down to a soft, very plastic clay

Since it was evident that the deposit as a whole was probably no a fireclay, but that certain portions of it which were clean an smooth looking might be, small samples were tested of the severa parts, and a large sample representing the run of the bank. Th results were as follows:—

The first sample was collected from 4 feet below top of shal bed, near northeast end of outcrop. Scattered concretions wer found in the layers over it. The clay is plastic but somewhat gritt to the feel, with an air shrinkage of 5 per cent. Its fire shrinkag at 010 is 0·5 per cent; absorption, 14·42 per cent, and colour buff.

At cone 1, it burns brown, with a fire shrinkage of 5 per cent and absorption of 3·08 per cent.

It is unaffected at cone 3 and would probably stand heating t cone 5.

The second sample tested represents a streak 3 feet thicl beginning 6 feet below the top of the bed. It contains a fe very thin coal streaks, and looks more ferruginous than the preced ing, and behaves somewhat similar to it.

This shale had air shrinkage of 5·1 per cent. At cone 010 it fire shrinkage was 0·5 per cent, colour red, and absorption 19·96 pe cent. At cone 1, fire shrinkage 4 per cent, absorption 4·72 per cent and colour red brown. It is nearly fused at cone 3, being, therefore slightly less refractory than the preceding.

This, the third sample, represents the lower 3 feet of the bed and was not included in the large sample.

Like the two preceding it burns buff at cone 010, and red brow at cone 1. It is nearly fused at cone 3.

A sample of the entire bed, excepting the lower 3 feet, gave th following results:—

When well ground, it worked up with 22 per cent of water t a smooth and plastic mass, whose air shrinkage was 6 per cent.

The average tensile strength of the clay was 85 pounds per squar inch, and 33·6 per cent of the material passed a 200 mesh sieve

In burning it behaved as follows:—

WET MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	1·7	15·01	Pink.
05	4·3	8·30	Dark red.
03	4·6	6·46	"
1	5·6	1·35	Chocolate brown.
3	5·6	1·45	"

A sample of the clay moulded dry press had 13·20 per cent absorption at cone 03.

The clay burned to a good colour and was steel hard at cone 05, but at 1 it was too dark, and apparently vitrified. It held its shape even at cone 3. The probabilities are that this clay could be worked for either common or pressed brick, or when hard burned might even be used for paving purposes. If this deposit were worked, it could be opened up on the outcrop, or possibly worked from the base, in which case it would be necessary to remove the material by boat, or else haul it up an incline to the top of the bluff.

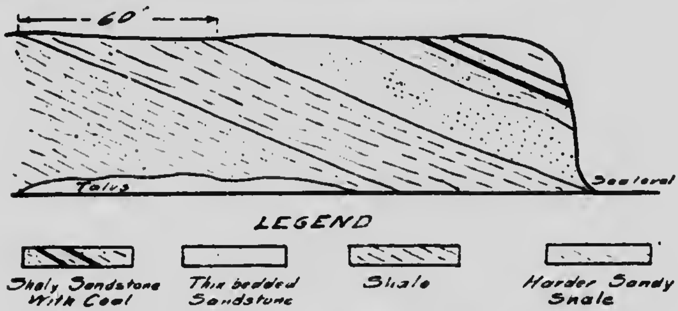


FIG. 5.—Section at Cranberry head.

Along the north shore, and just west of the base of Cranberry head is a considerable outcrop of a reddish, somewhat plastic clay shale, which becomes more sandy to the eastward. The main outcrop is just at the foot of the street leading northward from No. 2 shaft of the Nova Scotia Steel and Coal Company. As the bed has a width of outcrop of not less than 50 feet, and strikes south, it could be opened as a cut extending inland for some distance. (Fig. 5).

The physical properties of this shale were as follows: wa
required for mixing, 16·8 per cent; plasticity, fair; air shrink
5·25 per cent; average tensile strength, 71 pounds per square in
When ground up for moulding, 20·8 per cent passed through a
mesh sieve. The clay behaved as follows in burning:—

WET MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·4	14·00	Red.
05	5·3	5·71	Dark red.
03	7·0	2·24	" "
1	Fused		

A dry-press bricklet burned to a dark red at cone 03, and sho
an absorption of 6·02 per cent.

The shale would make a good common brick at cone 010,
gives a good hard body at cone 05.

It should make a good common brick, and could probably be u
also for red pressed brick.

The shore line from here to Long pond is low, and shows
outcrops, except for a short distance just west of the Cranberry H
shale. In this short distance there is found a thin bed of grey sh
associated with the Lloyd coal seam, and thought by some to b
fireclay, but it did not prove to be such.

Black Point.—The red shale of the Cranberry Head type, as w
as other shales, are found outcropping along the shore in this vicin

Thus, on the west side of Black point, the section is as shown
Fig. 6. Here there is a soft shale underlying the middle coal se
It is not accessible for working on the point, but comes to the s
face with a broad outcrop and low dip about 350 feet south of
point. The following data give the properties of this shale.

As this shale did not slake down at once when put into wa
two samples were tested. One of these was ground in
crusher set at $\frac{1}{16}$", the other was ground still finer. The coa

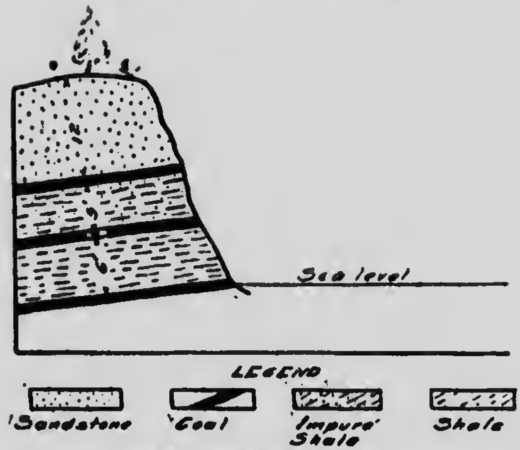


FIG. 6.—Section of Black point.

material is Lab. No. 1513a, and the finer material is 1513. For comparative purposes the tests on the two are given in parallel columns below:—

	Lab. No. 1513.	Lab. No. 1513a.
Per cent water required	23·8	18·5
Air shrinkage	5·7%	5·2%
Tensile strength lbs. per sq. in.	75·2	51·4
Cone 010—		
Fire shrinkage	1·6%	1%
Absorption	14·86	
Colour	Pink	
Cone 05—		
Fire shrinkage	3	4
Absorption	13·20	12·62
Colour	Light red.	Light red
Cone 03—		
Fire shrinkage	4·6	4
Absorption	10·61	9·70
Colour	Red	Red
Cone 1—		
Fire shrinkage	9·3	7
Absorption	1·08	1·39
Colour	Red brown	Red brown

Comments: No. 1513a has a good ring when burned to 010, and a fair colour, which does not deepen much up to cone 03, at which it is nearly steel hard. The colour is too deep at cone 1.

No. 1513, aside from the differences noted above, does not
much from the other.

The clay also makes a dry-press brick of fair colour.

Black Point to Oxford Point.—Sample 28 was taken on wes
of Black Point. Just west of this, and to the east of furnac
dump, there is an outcrop of red clay of the Cranberry Head t

Beyond the slag dump to the northwest there is a long beach
at the end of this the shale outcrops again.

That outcropping at this last-mentioned point is, at best,
only for common brick. Its air shrinkage is 4·2 per cent. It
buff at 010, and red brown at 1, with fire shrinkages of 1 and 6·
cent, and absorptions of 16·97 and 1·42 per cent respectively at
cones.

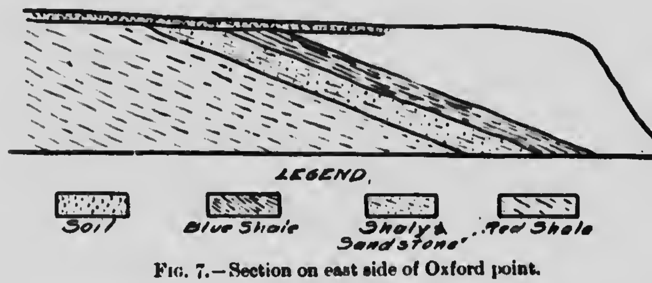


Fig. 7.—Section on east side of Oxford point.

On the east side of Oxford point, (Fig. 7), beginning at the
west end of the beach and going towards the east head of the
the low cliff sho the red Cranberry Head shale type first, and
250 feet farthe is capped by a thin 2 foot bed of shale wh
thought by so to be a fireclay, but tests prove this to be inc

It is fair smooth and plastic, with an air shrinkage of
cent. It shrinks 1 per cent at cone 010, and 6·3 per cent at c
the absorption at these two cones being 16·97 and 1·42 pe
respectively. The clay burns buff at 010, and red brown at c
It is not a fireclay, as it is thoroughly vitrified at 3 and fu
cone 5.

Farther west along the shore line, at a point just north
small beach, and due south of east from Alder Point P.O., t
Cranberry Head type again outcrops, and is here und
by a 5 foot bed of blue shale, of somewhat gritty characte

good plasticity, and which burns to a good red colour and hard body. It breaks up rather easily, and with ordinary grinding 25 per cent passes through a 200 mesh sieve.

It also requires only 15·4 per cent of water for working, and has a tensile strength of 68 pounds per square inch. The air shrinkage is 5·9 per cent. In burning, the wet-moulded bricklets behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	12·49	Light red.
05	2	7·90	Red.
03	2·3	6·85	"
1	2	1·89	Chocolate brown.
3	1·3	1·30	" "

The clay is in part beyond vitrification at cone 1, which accounts for the slight swelling. There is no reason why this should not be mixed with the Cranberry Head type of shale which overlies it.

The shale also gave a good dry-press bricklet at cone 03, with 11·80 per cent absorption.

Keating Pond to Plant Point.—Just southeast of the inlet to Keating pond there outcrops blue shale similar to that found on the southeast side of Oxford point, but gritty so far as could be ascertained.

To the north of the same pond, and opposite point marked '40 feet,' there is some shale, but it is under a rather heavy cover and not accessible. It is of doubtful value.

On the same shore, just due east of a point marked Little Pond P.O., there is a high cliff, which shows bluish shale at the bottom, but it is too gritty and covered by too much overburden.

Bonar point is bordered by inaccessible cliffs, and the shales observable in them do not appear promising. In the coastal cliffs to the northwest of Bonar point there are bluish siliceous shales at the base of the cliff.

Again, at a small beach, at the juncture of two roads, three-eighths of a mile south of Merritt point, the red Cranberry Head type of shale outcrops, and is 8 to 10 feet thick, as well as being free from overburden for a distance of about 150 feet.

Grey shale 8 feet thick outcrops on the north side of M
point. Sample 30 was taken north of Merritt point. The road
crosses the neck to Little Bras d'Or.

Sandy shales are seen here at several points, and there is a
surface clay for brick along the road where the arm makes a
quarter of a mile southwest of Kidd creek.

Black Rock Point.—This point, situated at the entrance t
Great Bras d'Or, is capped by boulder clay, underlain by Coal
ures shale. The latter does not crop out on the point, but is ex
south of the lighthouse. Here the northward dipping shales
in the lower half of the bluff, but they are quite variable in
character, and intermixed with sandstone seams. None of the
clean or free from grit, with the exception of one thin bed,
resembles a fireclay in appearance, and underlies the coal sean
cropping at that point, but while it burns buff at cone 010, at
3 it is beyond vitrification.

Nearer the lighthouse is another thin bed supposed to be fir
which is also buff burning, with 13·74 per cent absorption a
It is not vitrified at cone 3, but is not a fireclay.

There are outcrops of shale north of the lighthouse, but m
them are thin, or interbedded with numerous sandstone layers.

From Point Aconi southwest to Cinder head and Table head
is an unbroken line of cliffs, which appeared inaccessible, n
did they, so far as one can see from a boat, show many prom
shale deposits, the sandstone layers being too numerous.

In the cove on the west side of Table head the exposed bed
southward, and show about 30 feet of sandy shales, overlain
to 20 feet of sandstones. The shales are not workable becau
this heavy overburden.

Near the base of the section, there are two thin coal seams
under each of these is a smooth light-coloured clay, which wou
doubt be regarded as a fireclay by many, simply because it und
a coal seam.

The upper bed has 4·6 per cent air shrinkage. Its fire shri
is 0 per cent at cone 010, and 7·6 per cent at cone 1; absor
16·64 per cent at 010, and 2·09 at 1. The clay burns buff, is vi
at cone 3, and nearly fused at cone 6.

The lower bed shows 6·6 per cent air shrinkage. Its fire s
age is 1·4 per cent at cone 010, and 5·3 per cent at cone 1; a

tion, 15·43 per cent at cone 010, and 4·27 per cent at cone 1. The colour is red.

The two thin seams presumably represent splits of the Crawley seam shown on Fletcher's map.

Between here and the exposures noted at Black Rock light, there are shale beds showing in the cliffs, but they could not be reached.

The shale beds appear to be thinner and less persistent along this part of the coast than they are around Cranberry head.

Sydney to Cow Bay.—The Millstone Grit extends up the east side of Sydney harbour, to a point three-quarters of a mile southwest of Victoria Mines P.O., where the Coal Measures begin, and are exposed in a line of low cliffs as far as a point about one mile southwest of Low Point lighthouse.

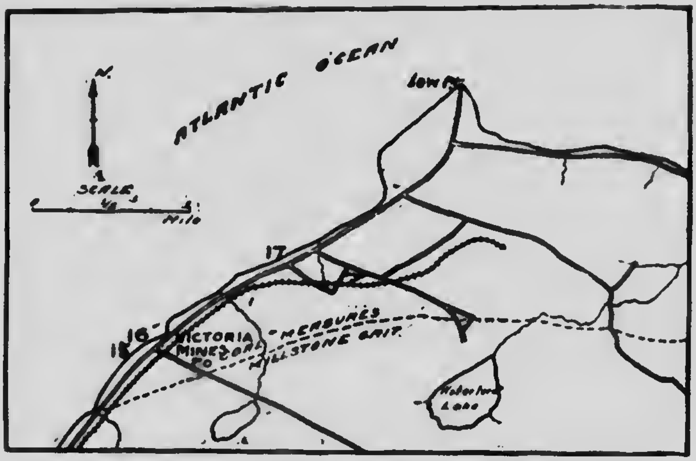


FIG. 8.—Map of Sydney coal field from Victoria Mines P.O. to Low point.

A bed of hard grey shale, not less than 15 feet thick, outcrops along the shore below the wagon road, and at a point just south of the first mine building at Victoria Mines P.O.

It is a dark coloured shale, with a sandstone capping, and a harder and sandy under shale of a type common near Cranberry head on the other side of the harbour. The dip is steep.

The material did not show up as well in the laboratory tests as it appeared to be in the field, for it has low plasticity.

The air shrinkage is 5 per cent, and only 20 per cent of material washes through a 200 mesh sieve. The burning tests of wet-moulded bricklets were as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	11·65	Red.
05	1	9·65	"
03	1	5·27	Brown.

A dry-press bricklet at cone 03 showed 12·28 per cent ab- tion.

The clay does not yield a hard bricklet below 03, which is hi than common bricks are usually burned at.

Fifty feet north of this, along the shore, is a bed of red about 7 feet thick, which is interbedded with greyish shales, bu total available bed of shale is small. The beds strike north 70° and dip 40° northwest.

It represents the best of the shale types along this part o shore, the others being more sandy.

This is a coarse-grained shale, working up with 13 per cent w and having an air shrinkage of 4·2 per cent.

It burns to a good red at cone 010, with 5·9 per cent fire sh age, and 6·91 per cent absorption, but at cone 1 is almost fused

Farther along the shore, at a point just northeast of a coming down from a pond, 1½ miles west of Waterford lake, is of shale similar to sample 15, with layers similar to sample 16.

The shales continue to outcrop for the next 500 feet, an represented in character by a soft shale, which, though soft, ap to be porous and lacking in plasticity.

The sample has 3 per cent air shrinkage, and burns red at 010, with 0 per cent fire shrinkage, and 10·13 per cent absor It fused about cone 1.

The shore now bows out a little and shows a series of sand beds, which are evidently higher up stratigraphically than the s and there is then an absence of exposures up to Low point.

PLATE VII.

Shale bank near Victoria Mines P.O., Sydney harbour, Cape Breton.

Low Point to Glace Bay.—There is a more or less continuous series of outcrops along the shore between these two points, but few favourable localities for working exist even if the shales were good.

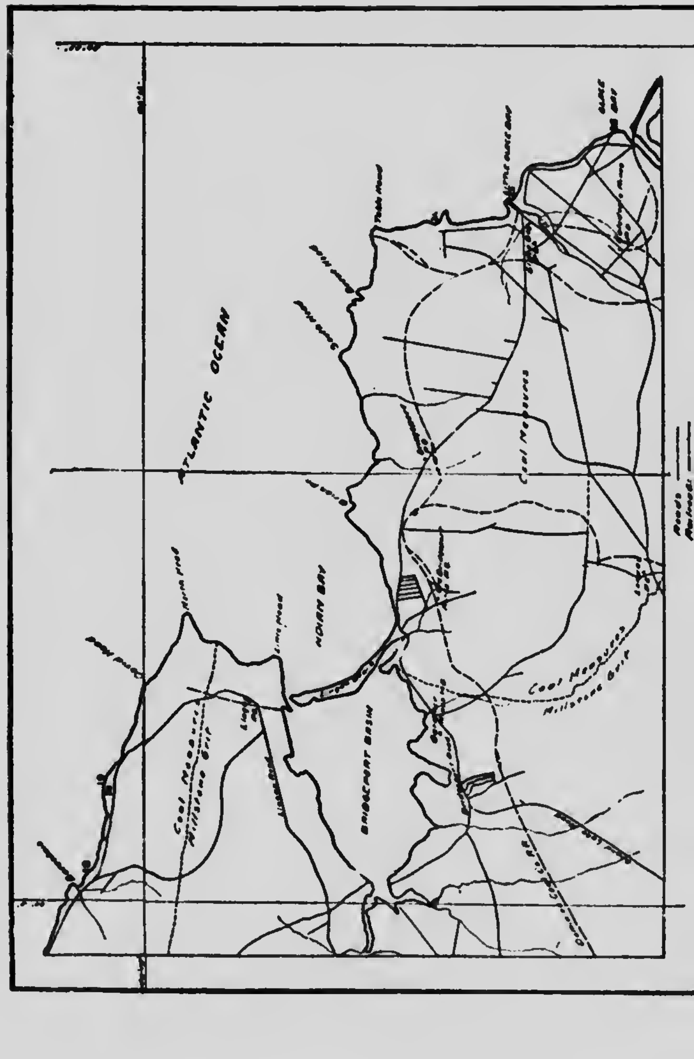
There are several reasons for this. In the first place, the shales are often interbedded with sandstones, and, therefore, could not be economically worked. A second reason is that there is a low dip seaward, and the shore line is approximately parallel with the strike. The beds do not outcrop on the surface for some distance inland, which also precludes economical working. Samples were collected, however, at a few of the more favourable points, even though the deposits were not very large.

Two thin beds of coal outcrop in the first cove east of Lower Barachois. Between these is a thin bed of shaly clay, not unlike many Pennsylvania fireclays in appearance, but it was found to be lacking in refractoriness. This shale, though quite gritty, is fairly plastic. It burns red, and at cone 010 and 1, showed a hard body, but it is not a fireclay.

About 1½ miles east of Lower Barachois the outcropping red shale (Plate VIII) is quite gritty, and when ground and mixed with water does not show much plasticity. Bricklets made from it had an air shrinkage of 4·1 per cent. Their fire shrinkage at 010 and 03 was 0·3 per cent and 1·6 per cent, respectively. The corresponding absorptions were 13·18 and 4·52 per cent. The shale burns red, and fuses at cone 1. About 150 feet west of this point is an outcrop of red shale free from overburden. This shale is also rather low in its plasticity, but could be improved by weathering. It burns to a red colour at 010, with 0 per cent fire shrinkage, and 14·26 per cent absorption, but fuses at cone 1.

At one locality, however, along the shore northeast of Glace bay, and at a point directly opposite No. 2 colliery, grey shale is exposed in low bluffs along the shore for a distance of not less than 150 feet.

At the northeast end of the exposure the shale is overlain by a thin sandstone bed, but this disappears towards the southwest, its place being taken by a thin layer of stony clay. The bed could be worked inshore for some distance, without the probable necessity of removing much overburden. A sample was taken for testing, and worked up with 13·2 per cent water to a mass of moderate plasticity, whose tensile strength when air dried was 58 pounds per square


ATLANTIC OCEAN
Coal Measures
Millstone Grit
BRIDGEPORT BASIN

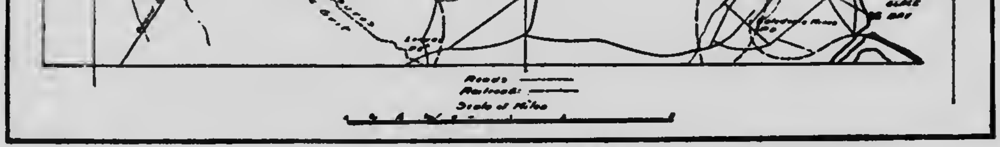


Fig. 9.—Map of Sydney coal field from Barachois to Glace bay.

Plate VIII.

Jointed sandstone, overlain by red shale, Lower Barachois, Cape Breton.

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inch. About 30 per cent passed a 200 mesh wire sieve. The air shrinkage was 6·1 per cent.

The burning tests of the wet-moulded bricklets were as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	1	12 72	Light red.
05	3·6	6·74	Dark red.
03	4·6	5·53	" "
1	Fused.		

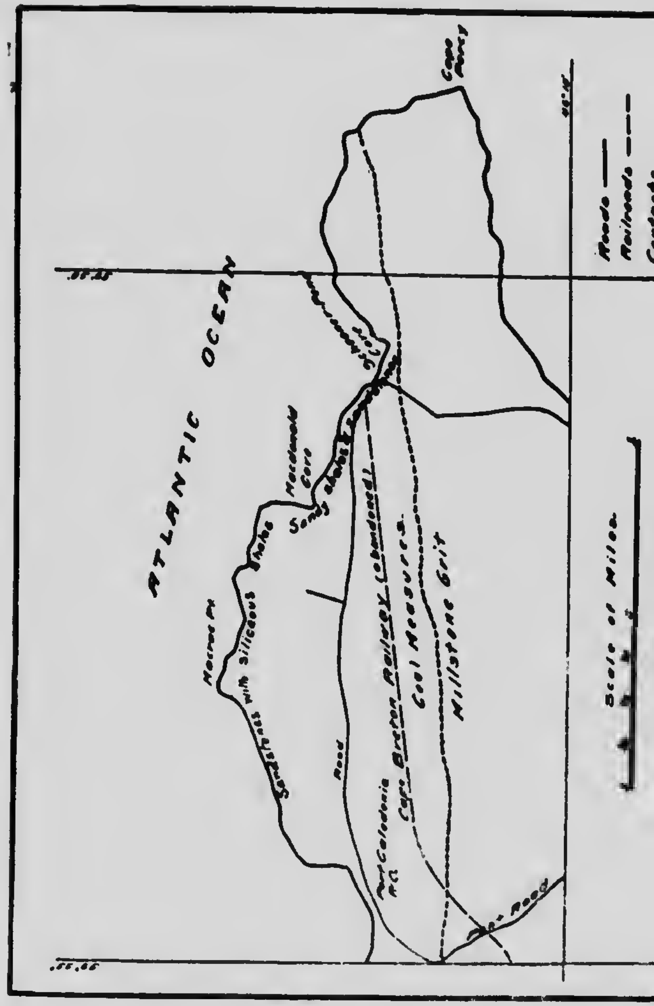
The wet-moulded bricklets had a good ring and colour even at cone 010. A dry-press bricklet at cone 03 gave a good body of red colour.

Weathering would undoubtedly improve the workability of this brick shale.

Glace Bay Eastward.—Eastward along the shore from Glace bay the Coal Measures outcrops continue until near Cape Percy, where the Millstone Grit appears.

They are well exposed in the cliffs, and present the usual series of interbedded sandstones and shales, although the former rather predominate.

At a few points, beds of brownish, fissile, though somewhat gritty shales occur, which could be worked. One of the best exposures of this type is along the shore just east of the entrance to Glace Bay harbour, where the bluff is quite low (Plate IX). The shale bed which appears to dip northward at a very low angle is not less than 10 feet thick, and is free from overburden for a distance of 75 to 100 feet. Inshore, the land rises but little, and the shale could be easily excavated in that direction. A sample of it gave the following results on testing, having first been ground so as to pass a 40 mesh, in order to improve its plasticity, which it did. Water required, 17·6 per cent; air shrinkage, 5 per cent; average tensile strength, 67 pounds per square inch.



ATLANTIC OCEAN
Cape Percy
Macdonald Cove
Sandstones with Siliceous Shales
Cape Breton Railway (abandoned)
Coal Measures
Millstone Grit
Road
Port Caledonia P.O.
Scale of Miles
Roads
Railroads

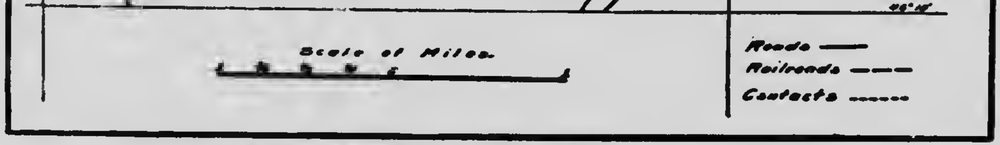


Fig. 10.—Map of northeastern portion of Sydney coal field.

Plate IX.

Shales near No. 2 mine, Glace Bay, Cape Breton.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	14·66	Red.
05	1·5	10·48	"
03	3·3	2·27	"
1	5·3	1·15	

This is a good red burning shale, which burns to a hard brick, but unless ground and weathered first it may cause trouble in moulding.

The Millstone Grit, as exposed on the north shore of Cow bay, shows but few shaly layers.

Few outcrops of shale are to be seen in the Coal Measures around Port Morien, but a so-called fireclay underlies the Blockhouse seam in the mines of the North Atlantic Coal Company at that locality. We were not able to see it in place, but took our sample from a large pile that had been brought to the surface under the direction of Mr. Richardson, former superintendent of the mine.

The following tests indicate that it is not of refractory character.

The clay works up to a quite plastic mass with 15·4 per cent water, and 33·4 per cent of the clay passes a 200 mesh sieve. its average tensile strength is 64 pounds per square inch, and the air shrinkage 5·6 per cent.

The wet-moulded bricklets behaved as follows in burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·4	17·25	Red.
05	3 3	12 32	"
03	5	9·88	"
1	6	3·52	"

The dry-press bricklets burned to a hard body at 03, with 10 per cent absorption.

Toronto Mine.—Near Little Bras d'Or bridge the Colonial Coal Company was in the summer of 1909 re-opening an old mine, which had not been worked for 30 years. Two openings have been made, one of these being a drift run in from a point along the Little Bras d'Or, and the other a slope sunk at a point up the hill and to the wagon road.

At the former, a somewhat soft shale overlies the coal, sample was taken, as it would be impracticable to work it. slope, the coal is overlain by a thin sandstone roof, and this by about 3 feet of shale. The coal is underlain by a plast said to be a fireclay, which as then exposed was from 12 to 1 thick and immediately under the coal. A sample of it wa partly because it was desirable to look into all possible occu of refractory clays in the Sydney region, and not because ness of 12" was regarded as sufficient for working. In som a 12" layer of clay may yield a considerable supply of mat the accompanying coal seam is extensively worked. Howev such a thin bed could, if persistent, be removed and used, an mining operations were at all extensive, not a little clay c obtained in this manner. There is, of course, a possibility t bed may thicken, and an equal possibility that it may th altogether.

As the tests given below will show, the material is not a but it is one of the best clays found in the Coal Measures Sydney district.

It is a smooth, sticky clay, 32·2 per cent of which passes a 200 mesh sieve. The clay, when worked up with 27·2 p water, had an average air shrinkage of 7 per cent. Its aver sile strength was good, being 129·1 pounds per square inch.

In burning, the wet-moulded bricklets behaved as follows

Cone.	Fire Shrinkage.	Absorption.	Colo
	%	%	
010	0·2	16·10	Buff.
05	5	6·52	"
03	6	1·87	"
1	7·3	0·27	Yellow bro

The bricklets were not very hard at 010, but had a good 05, and were steel hard at 03.

The clay could no doubt be worked dry-press, but laborato indicated that it would have to be burned to cone 1 in order duce a good brick.

Sydney Area.—Another refractory shale was reported from the new fan shaft of No. 4 colliery of the Nova Scotia Steel and Coal Company, but it is a hard gritty material of no probable value.

Immediately over the clay, however, is a 3 foot layer of smooth, though somewhat carbonaceous shale, containing numerous plant impressions. This material is sandy, but still rather plastic when ground up and mixed with water. Its air shrinkage was 4·5 per cent, and at cone 010 the fire shrinkage was practically zero, but had increased to 1 per cent at cone 03, and 4 per cent at cone 1. The absorption at these three cones was 12·71, 7·77, and 5·17 per cent, respectively. The shale burns buff, and if enough of it could be obtained, could probably be employed for face brick.

Pictou Field.—In this field, in which the coal mining operations are centred around the towns of New Glasgow, Stellarton, Westville, and Thorburn, there is a strong development of shales in the Coal Measures.

The latter consist of shales, sandstones, and coal beds, the whole series having a general northward dip, interrupted here and there by local folds, and also a number of faults.

The shales are not uniformly distributed through the field, nor are they all of the same character.

Thus, those around New Glasgow are often of smooth character, but run rather high in their carbon content, while around Thorburn there is very little shale, and sandstone predominates.

At Westville, most of the shales are highly carbonaceous.

Up to the present time the shales have been worked mainly around New Glasgow, and outside of this only at Westville.

The best exposures of shale in the district are those along McClellan brook, Shale brook, and East river.

The most important opening is that worked by the Standard Drain Pipe Company, whose bank lies along McClellan brook (Fig. 11) about a quarter of a mile west of the works. About 30 feet of greyish-black shale is exposed, overlain by a reddish glacial clay, containing scattered pebbles. The shale, which strikes northwest, and dips about 15° northeast, contains small discontinuous layers of siderite concretions. These, if not thoroughly ground up, cause fused spots in the burned ware.

FIG. 11.—Map of portion of New Glasgow coal field.

FIG. 11.—Map of portion of New Glasgow coal field.

PLATE X.

Lower shale in pit of Dominion Fire Brick and Tile Company, New Glasgow, Nova Scotia.

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PLATE XI.

General view of Standard Drain Pipe Works, New Glasgow, Nova Scotia.

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The fresh material is a moderately hard, smooth shale, which, when ground up and mixed with 17·6 per cent of water, gave a mass of fair plasticity, 31·29 per cent of which (in the dried state) passed through a 200 mesh sieve. Its air shrinkage was 5·5 per cent, and the average tensile strength 107 pounds per square inch.

The wet-moulded bricklets behaved as follows in burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	-0·3	14·20	Buff.
05	3·6	6·81	Red brown.
03	4·00	6·9	" "
1	6	2·10	" "
3	Nearly fused.		

The shale burns to a good hard body, and is utilized in the manufacture of sewer pipe, and hollow blocks. It has to be burned with great care, however, owing to the quantity of carbonaceous matter which it contains. Indeed, even the bricklets burned in the laboratory had to be held for some hours below 900° C in order to free them from the carbon which they carry.

Specks or lumps of carbonate of iron may be present in the clay, and these are liable to cause blistering in the bricks above cone 1.

North of this point, and not far from the works of the Standard Drain Pipe Company, is an old pit, opened on a bed outcropping perhaps 30 feet above the stream level, and extending to a point above Brook's common brick-yard. This was formerly worked to supply the pipe works, but was abandoned because of the numerous layers of concretions. This bed is higher stratigraphically than that worked at the plant of the Dominion Fire Brick and Tile Company, a short distance up the stream.

At the latter works, an opening has been made close to the stream level, for extracting a smooth, greyish-black shale (Plate X) which turned out to be the most refractory worked in this district. The properties of this shale are given below.

This works up with 18 per cent water to a smooth, plastic mass, whose air shrinkage is 5 per cent, and average tensile strength 98·5 pounds per square inch. About 59 per cent of the ground material passes a 200 mesh sieve.

In burning, the wet-moulded bricklets behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	11·42	Cream.
05	2·3	8·43	Buff.
03	3·6	7·57	"
1	6	2·04	Buff brown.
3	5	0·90	Brown.
5	5	1·20	Grey.
9	0	0·80	Brown.
14	Nearly fused.		

The bricklets are not sufficiently hard at 010, but make a go body at 05. The shale is steel hard at 03, and holds its shape to cone 9, though portions are beyond vitrification, which causes t swelling. It is considerably more refractory than the Standard Pi Company's shale.

A thick bed of black shale, appearing like oil-shale, outcro by a ford over McClellan brook about half a mile south of east the Trotting park. The material is not adapted to brick making, it is very gritty and of low plasticity. It burns red, with a low and fire shrinkage, and fuses a little above cone 3. Its absorpti ranged from 19·02 per cent at cone 010 to 14·24 per cent at cone

Some distance east of New Glasgow, on the road to Woodbu grey shale outcrops in the bed of a small brook. It is probably workable, owing to its position. It is not a fireclay, as it burns to dark red colour, and is practically vitrified at cone 1. The fire te were:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·6	15·65	Light red.
1	7	2·76	Dark red.
3	Fused.		

Coal brook, a tributary stream of the East river, passes direct across the strike of the beds in the district northwest and north Stellarton.

PLATE XII.

New Glasgow Brick and Tile Works.

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The beds dip northeast, and, therefore, in going down stream one is passing over the outcrops of successively higher beds.

Most of the shales encountered along this section are carbonaceous in their character, but there are several beds which are free from such impurity.

One of these lies between the Third and McGregor seams, and outcrops just northwest of Coal brook and on the south side of the old Middle River road.

The clay worked up with 17 per cent water to a mass of fair plasticity, whose air shrinkage was 5 per cent, and average tensile strength 69 pounds per square inch. Of the shale prepared for moulding, 26·4 per cent passed through a 200 mesh sieve.

The wet-moulded bricklets gave the following results in firing:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·8	15·14	Dark buff.
05	3·3	12·20	Red brown.
03	5·6	4·37	Spotted brown.
1	5·7	4·93	"
3	4	2·26	"

A dry-press bricklet gave a good body at cone 03, with 12·20 per cent absorption. It should be burned at cone 1 if dry-pressed.

The wet-moulded bricklets gave a rather coarse-grained body of fair ring at cone 05, but the colour was not very good. At cone 3 the clay was beyond vitrification, and the fracture of the bricklet showed numerous quartz grains in a fused matrix.

Another sample was taken from a point along Coal brook, about half a mile southwest of the Allan shaft of the Acadia Coal Company. It is not less than 12 feet thick, and lies between black fissile shales, which outcrop continuously along Coal brook from the old Middle River road to the Allan shaft.

The black shales, though abundant, are probably too carbonaceous to be of any value.

The other shale, however, is fairly plastic in its character, when worked up with 18·6 per cent water. Its air shrinkage is 5 per cent, and its average tensile strength 146 pounds per square inch. When ground in the crusher for moulding, 33·2 per cent passed a 200 mesh sieve.

The wet-moulded bricklets gave the following results on testing :-

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·0	15·11	Lt. red.
05	1·8	11·51	Red.
03	2·3	9·00	Red brown.
3	Fused.		

The shale burned to a fair body at 010, and a good hard one 05 and 03, but the colour was not very clean. The shale is p vitrification at cone 1.

A dry-press bricklet at cone 03 gave a much better colour an hard body.

Along the shore of the East river, and across the river fr the Allan shaft, shales may be found outcropping in some of ravines. Most of them appear too carbonaceous, however, to be any value for making clay products. One of these outcrops is i gulch, directly opposite the Allan shaft. Although it appeared v unpromising, it was tested to see how it would behave.

The shale, though not very hard, gave a sandy, coarse-grai mixture of low plasticity, and 3·3 per cent air shrinkage. It bur red and steel hard at cone 03, and showed moderate absorption (per cent). Its low plasticity would interfere somewhat with moulding, and the carbonaceous character of the material would for slow and careful firing.

For several years bricks have been manufactured at West from the hard, greyish-black shale found under the No. 3 sea the mine of the Intercolonial Coal Company. The bed is 4 thick, and the shale burns to a buff colour, but while its fusion p lies at cone 14, it is not to be regarded as a fireclay, although called by some.

The shale in its ground condition worked up with 13 per ce water to a gritty but fairly plastic mass. Its air shrinkage i per cent, and average tensile strength 60 pounds per square The wet-moulded bricklets behaved as follows:—

At cone 010, fire shrinkage 0 per cent, absorption 11·03 per and colour buff.

At cone 05, fire shrinkage 2 per cent, absorption 9·19 per cent, and colour buff.

At cone 03, fire shrinkage 2·3 per cent, absorption 8·08 per cent.

At cone 1, fire shrinkage 0·4 per cent, and absorption 4·80 per cent.

At cone 3, fire shrinkage 4 per cent, absorption 5·04 per cent, and colour still buff.

The bricklets were not carried above this temperature, but the fusion point was determined to be about cone 14. Owing to the carbonaceous character of the clay, great care has to be taken in firing it to burn off the carbon, and prevent black coring, and swelled bricks.

The clay can be worked in either a stiff mud or dry-press machine, and gives a good dry-press body at cone 03, with an absorption of 9·25 per cent.

Inverness Field.—A small coal area is found along the shore of Cape Breton, in the region surrounding Inverness, the Coal Measures being exposed along the shore both north and south of the town, and forming a shallow basin, which pitches westward under the waters of the Gulf of St. Lawrence.

Little attention has been given to the shales of this area, the coal alone having been regarded as worthy of consideration.

Along the shore south of Inverness there are a number of good exposures in the cliffs, but few of them appear to be promising, as the beds are mostly sandstone.

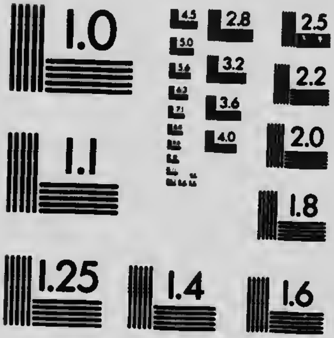
About one-eighth of a mile south of McIsaac pond a 2½ foot coal seam outcrops, and this is underlain by a bed of smooth, plastic, mottled clay shale, not less than 8 feet thick.

The following tests give its properties.

This smooth, plastic shale, when ground up ready for moulding, had 61 per cent of grains that would pass a 200 mesh sieve. It was worked up with 21·2 per cent water, had an air shrinkage of 5·7 per cent, and an average tensile strength of 145 pounds per square inch.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc
1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

The burning tests of the wet-moulded bricklets are given below:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·8	12·13	Buff.
05	2·6	9·61	Red.
03	6·6	3·18	Red brown.
1	6·6	1·80	"
3	5	00	Brown.

The bricklets burned at cone 010 had a good ring, and were steel hard at cone 05. At cone 1 numerous blisters began to appear. It is badly blistered and past vitrification at cone 3.

North of McIsaac pond are a number of low cliffs along the shore, showing southerly dipping beds of shales and sandstone.

A small sample was taken of the shale outcropping half way between the Inverness mine and Big river, or about 800 feet east o the line dividing the Coal Company's property from the old Mus grave property. The material is a clay shale, of low dip, viz., 15 west, and strike north. It is covered by drift.

The shale is smooth and of fairly plastic character, when worke up with 22 per cent water. Its air shrinkage is 5·0. At cone 01 the fire shrinkage is – ·8 per cent, absorption 18·06 per cent, an colour buff. At cone 03 the fire shrinkage is 7·7 per cent, absorptio 5·42 per cent, and colour red. The shale burns steel hard at 0 and has a good colour. It is hardly of sufficient thickness to l used.

More sandy shale outcrops a little farther along the shore to tl north. Tests show that the shale, although sandy, works to a very plastic mass with 19·4 per cent water, and 4·4 per ce air shrinkage. At cone 010 the fire shrinkage is 0 per cent, absor tion 16·01 per cent, and colour reddish buff. At cone 03 the fi shrinkage is 3 per cent, absorption 8·88 per cent, and colour re It gives a good hard bricklet at the latter cone.

The most important deposit in the district is the clay overlyi the 13 foot or Hussey seam.

This is well seen in the outcrop along Big river, north of Inv ness, where a drift was run in, known as the Hussey drift.

The coal seam at this point is overlain by a clean looking plas grey clay, which ranges in thickness from 18 inches to nearly 3 fe

This is in turn overlain by an 18 inch seam of coal, and over this again there is a dark shale, which could not be properly sampled owing to the wash from the upper part of the bank.

The clay is very plastic in its character, and appears to be free from coarse sand, but occasional pyrite nodules were noticed.

If this clay seam is worked it would have to be in connexion with the 13 foot coal, and as the latter contains good coal in its upper bench, this is not an impracticable proposition.

The following tests give the properties of the clay from the Hussey drift.

It is a very smooth, sticky clay, which, however, contains so much fine sand that only 58·4 per cent passes through a 200 mesh sieve. It took considerable water (30·8 per cent) to work it up, and had an air shrinkage of 8·5 per cent. The average tensile strength was 206 pounds per square inch. The burning tests on the wet-moulded bricks are as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·3	15.74	Pink buff.
05	4·3	9·79	Buff.
03	....	2·25	Dark buff.
1	6·6	....	Buff.
3	7·3	0	Drab.
5	10	0	"
9	5	0	Grey.

The clay behaves like a stoneware clay, and its fusing point lies about cone 25. It makes a good dry-press body at cone 1.

A chemical analysis of this clay made by M. F. Connor, of the laboratory of the Mines Branch, gave:—

Silica	55·52
Alumina	26·80
Ferric oxide	2·58
Titanic oxide	1·50
Magnesia	1·05
Lime	0·25
Soda	0·73
Potash	3·43
Water	8·39
	100·25

This is one of the best clays found in Nova Scotia, and several possible uses suggest themselves. It could no doubt be used for pressed brick. If mixed with some burned clay (grog), it could a be used for firebrick. The high plasticity and dense burning qu ties also make it available for stoneware manufacture. Lastly, represents a type of clay used for mixing with short-fibre asbes for making asbestic.

On McClellan brook, which lies between Big river and Kenn brook, the 13 foot seam is present, but the dip here is very low (over 10° west). The clay here is not as clean looking as in Hussey drift. Its properties given below, show that it is also slig different in its characters.

This material is very plastic, and 50 per cent of it passes a mesh sieve. It worked up with 28 per cent of water, had an shrinkage of 7·8 per cent, and an average tensile strength of pounds per square inch.

The wet-moulded bricklets behaved as follows in burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·8	16·81	Buff.
05	4	8·81	"
03	7	0·7	Dark buff.
1	7	0	Drab.
3	7	0	Grey brown.
5	6·3	0	Grey.

The clay, it will be noticed, burns to a dense body at a ver cone (03), and preserves its buff colour up to the same. It also serves its form up to cone 1, and could no doubt be used for m common stoneware.

A good dry-press brick was obtained at cone 1, with 6·40 pe absorption, and buff colour.

The 13 foot seam is also found outcropping along the li its strike on Kennedy brook, to the north of Big river, bu dip here is vertical; and while the fireclay is known to be pr according to Mr. Beaton, the surface had caved in so that i not possible to get a sample. The floor of the coal at this po a siliceous shale clay, with plant impressions. Its exact thi is not known, but it is quite plastic, even though sandy. shrinkage is 4·4 per cent, and the fire shrinkage, at both 010 a under 1 per cent. The absorption at these two cones is littl 16 per cent.

PLATE XIII.

Shale and sandstone beds north of Port Hood, Cape Breton.

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It is doubtful if the clay would have much value if used alone, but it could be mixed with the overlying clay.

Port Hood Field.—This small area of Coal Measures, surrounded by Millstone Grit, lies also along the west shore of Cape Breton. The Coal Measures form a somewhat unsymmetrical trough, whose axis extends approximately northeast-southwest, and carries one coal seam which is worked.

Both north and south of Port Hood there is a somewhat continuous series of exposures.

Northward from Port Hood, the section in the cliffs shows a series of shales, with interstratified sandstone beds. (Plate XIII). The latter occasionally predominate to the exclusion of the former, while at others the shales are in excess, but contain so many thin sandstone seams as to be unworkable.

It is doubtful if any of these shale beds north of the town are workable, unless of high grade, such as fireclays, in which case they could be worked by underground methods. Since, however, they are usually referred to as fireclays, and considered by many to be such, a few samples were tested. These were as follows:—

One example from the heavy shale bed, along the shore a few hundred feet north of Cape Linzie, proved to be red burning and not refractory.

Another sample tested was a shale clay, overlying sandstone, above quarry on Cape Linzie.

There is not a heavy bed of this clay, and a sample of it was taken for testing because it was claimed to be a fireclay. The shale is quite plastic, and burns to a red, but not very dense body, though a steel hard one at cone 03.

It has 6 per cent air shrinkage, and at 03 the fire shrinkage is 6·3 per cent, with 9·24 per cent absorption. It is not refractory.

Shale also outcrops along the shore, north of the government wharf at Port Hood, and is exposed between high and low tides.

This is to be classed as a common brick shale, which, though gritty to the feel, works up to a rather plastic mass with 19·4 per cent water. Its air shrinkage was 5 per cent. At cone 010 the fire shrinkage is 0·4 per cent, and absorption 13·69 per cent. At cone 03 the fire shrinkage is 5 per cent, and the absorption 4·11 per cent. The shale burns red, and gives a hard body at 03, but is not a fireclay.

South of Port Hood, the rocks outeropping in the cliffs alo the shore are nearly all sandstone, until a point about two mi south of the town is reached, where the coast line turns sligh southwestward and crosses the strike of the beds at a very acu angle. Some shales then begin to appear.

One of these is of a light greenish colour, of rather smooth f and plastic character, which worked up with 33 per cent water. a had an air shrinkage of 6 per cent.

At cone 010 the fire shrinkage was under 1 per cent, absorpti 20.18 per cent, and colour buff.

At cone 03 the fire shrinkage was 6.3 per cent, absorption 12 per cent, and colour pink. This shale can be used for common br manufacture, and burns steel hard at 03.

A little farther south, and at a point lying south 50° west fr the north end of Henry island, and south 25° east from the so point of Smith island, there is a rather long outcrop of vertic dipping, bluish clay shale, from 8 to 10 feet in thickness. (P XIV.) This is really the only important bed in the section fr Port Hood to Judique harbour.

Its characters were as below:—

Clay plastic and smooth, working up with 29.4 per cent wate a mass whose air shrinkage was 5.8 per cent, and average te strength 65 pounds per square inch.

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·2	2.52	Red.
05	7·6	4·94	
03	9·6	1·51	
1	12·6	0·11	

The clay burns steel hard at cone 05, giving a very smooth of good colour. It would do for manufacture of common ear ware or drain tile. Just before reaching Judique harbour the Measures end, and the lower Carboniferous shales with their gy beds appear. One example tested shows the shale to be very s

PLATE XIV.

Clay outcrops south of Port Hood, Cape Breton.

and of low plasticity. Its air shrinkage (3·6 per cent) is therefore low. It burns to a good red colour, and could be improved by weathering.

At cone 010 the fire shrinkage is – 0·3 per cent, absorption 15·70 per cent, and colour red.

At cone 03 the fire shrinkage is 4·3 per cent, absorption 8·20 per cent, and colour red brown.

The shale could be used for common brick, but owing to scattered concretions and stones in it, preliminary crushing in rolls would be necessary.

Joggins Field.—This field contains a number of shale beds, which are well shown in a remarkable section exposed in the high cliffs along the Bay of Fundy shore[1]. (Plate XV.)

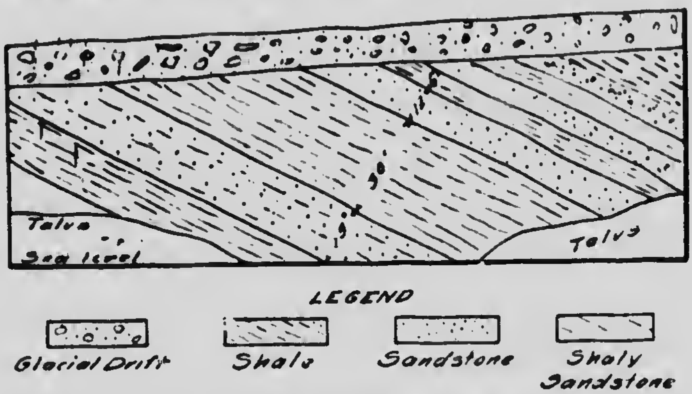

FIG. 12.—Section one mile north of Joggins.

While the shale beds in the Coal Measures are very numerous, (Fig. 12), there are several factors which prevent the profitable working of most of them, :—

(1.) Few of the beds are thick.

(2.) Sandstone layers are abundant in them.

(3.) The beds are usually too steep to give a good broad outcrop, and not steep enough to be worked without removing the overburden.

(4.) The high tides would interfere somewhat with shipments, although it could be done.

[1] Those who wish the details of this remarkable section should consult Proceedings and Transactions of Nova Scotia Mining Institute, Vol. XI, Part 3, pages 417-550.

The coal worked at Joggins is known as the Joggins seam. I
the centre there is a parting of dark grey shale clay, which may b
under a foot thick, and in other places thickens to 3 feet. In thi
case it may be solid shale, or a mixture of shale and sandstone.

At present only the upper split of the Joggins seam is worked
and the shale parting is left as a floor, unless the bottom has to b
taken up to get head room.

The sample taken from the mine of the Maritime Coal, Railwa
and Power Company at Joggins, represents the run of the shale par
ing. It is a hard shale when first quarried, but disintegrates o
exposure to the atmosphere, and works up with 17 per cent of wat
to a fairly plastic mass, with an air shrinkage of 5·1 per cent, an
an average tensile strength of 58·5 pounds per square inch.

It behaved as follows in burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·6	10·00	Red.
05	3·6	6·72	"
03	3	5·00	"
3	Fused.		

It gives a good red brick at 010, and is steel hard at 03. T
shale could probably be used for common or pressed brick, but n
paving brick.

At the north end of the cliffs, showing Coal Measures exposur
there is a thick bed of clay of the Cranberry Head type, probably
feet thick. There is a 10 foot capping of sandstone over it, but t
outcrop is quite broad. (Fig. 12). No tests were made, but
could be doubtless used for brickmaking.

No other outcrops occur northward along the shore until Low
cove, where in the grindstone quarry, in the Millstone Grit, th
is a reddish shale overlying the sandstone, similar to the Cranber
Head type, and probably not less than 25 feet thick. If worked
brickmaking it would have to be as a long narrow cut.

About one third of a mile south of the bridge across McCar
brook, south of Joggins, there is a reddish shale bed, 15 to 20 f
thick, underlain and overlain by alternating shales and sandstones

PLATE XV.

Alternating beds of shale and sandstone, Joggins, Nova Scotia.

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This is the first heavy shale bed met, for down to this point there had been a succession of thin beds of alternating shales and sandstones.

The qualities of this material cannot be given, as the sample was lost in transit.

A shale bed 15 feet thick outcrops at Ragged Reef point, two miles south of Joggins, and is suitable for brick manufacture, but the quantity is not large.

PERMIAN.

This includes: (1) a series of disconnected areas extending from Chignecto bay, along the north shore to a little beyond Merigomish harbour; (2) an area south of Joggins.

As far as could be ascertained, there are no clay or shale beds of importance in the Permian, except around Woodburn, east of New Glasgow. This area, according to Poole's map of the Pictou coal field, lies in the Permian conglomerate, but a map published by the Geological Survey, Canada, places the southern boundary of the Permian a little farther to the north, which, if correct, would put the Woodburn clays in the Millstone Grit. In this discussion it has been left in the Permian.

Outcrops in the district are not very abundant, and only two exposures of clay were seen.

One of these is along Small brook, about one mile northwest from Woodburn station, the other lies one mile north of Woodburn station, where the wagon road crosses a bridge over the creek.

The first locality was prospected originally by Mr. M. E. Sutherland, who opened up the deposit along Small brook, and sunk a test boring which gave the following section:—

Glacial drift	4-6 feet.
Red clay	4 "
Mottled and bluish white	11 "
Red shaly clay	125-150 "

The actual thickness of the outcrop in the bank of the stream is not over 6 feet, and the thickness given in the above section was found by boring in search for coal.

The land rises somewhat steeply from the brook, and if the deposit were worked on a large scale it would involve quite a bit of stripping in the beginning.

The following are the properties of this clay:—

Water required for mixing, 18·5 per cent; plasticity, excellen per cent through 200 mesh, 35·6 per cent; air shrinkage. 7·6 p cent; average tensile strength, 190 pounds per square inch:—

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	12·60	Pink buff.
05	1·3	9·93	Buff.
03	1·3	9·73	"
1	2·3	4·14	Spotted buff.
3	2·7	2·42	Grey buff.
5	3·3	2·15	" "
9	2·3	1·88	Brown.

The bricklets showed a good colour up to cone 03, at which po they were nearly steel hard. Indeed the bricklets were moderat hard even at 010. At cone 1 the bricklets became somewhat speckl and at cone 3 a number of fused spots appeared. These were grea emphasized at cone 9, and are probably the cause of the swelli although even at this cone the bricklets held their shape.

A dry-press bricklet at cone 03 showed 8·21 per cent absorpti but if worked this way the clay would give better results at cone 1

Some of the wet-moulded bricklets were re-pressed and burn at 03, yielding a nice buff product of steel hard character.

This clay is not to be regarded as a fireclay, but it could be u for making face brick, and perhaps cheap terra-cotta or fireproofi

The two following analyses made by A. L. McCallum, of Halif represent the composition of samples taken by Mr. Sutherland fr the wall of a test pit sunk along the bank of Small brook. Th indicate a slight variation in the composition of the clay, and wo lead one to believe that it is more refractory than it really is.

—	I	II
	%	%
Silica	70·15	73·58
Alumina	19·01	15·93
Iron oxide	1·27	3·17
Lime	0·59	0·14
Magnesia	0·86	0·27
Alkalis	0·91	0·59
Water	7·14	6·21
	99·93	99·89

There are not sufficient outcrops to definitely ascertain the stratigraphic relations of the clay on Small brook, and that one mile north of Woodburn, but from the meagre evidence it seems fairly safe to say that the latter overlies the former, and that a limestone bed to the west of the second outcrop lies between the two.

The material from the locality north of Woodburn station is a red and mottled shaly clay, which is not less than 15 to 20 feet thick. The clay dips to the northward at a low angle, and at the bottom of it is about 10 feet above the creek level at which the limestone outcrops. It could not be worked far into the hill without having to strip off heavy overburden, but could be worked for some distance along the strike, however, without much stripping.

Scattered through the clay are small sandy concretions, but these could be easily crushed.

The clay somewhat resembles that on Small brook in appearance, but is evidently higher up stratigraphically. It had the following physical characters:—

The clay worked up to a smooth and very plastic mass with 19·8 per cent water, the air shrinkage of which was 6 per cent, and average tensile strength 157 pounds per square inch. About 64 per cent passed through a 200 mesh sieve.

The wet-moulded bricklets yielded the following results in the fire test:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·3	12·75	Red.
05	3	10·33	"
03	3·3	8·14	Dark red.
1	4·3	1·77	Red brown.
3	5	1·54	" "

The bricklets were nearly steel hard at cone 03, and fully so at 1. They also had a good red colour up to 03, but at 1 were rather dark, and showed small fused spots. The clay makes a good dry-press bricklet if burned to cone 1. This material could probably be used for face bricks, or fireproofing, or even common ornamental terra-cotta.

CHAPTER II.

Pleistocene Clays.

These may be roughly divided into two classes, viz: (1) glaci clays, often of stony character, but very plastic, tough, and red burn ing, and (2) estuarine clays, usually strongly laminated, but al quite plastic, and red burning.

There are some, such as those at Eden Siding, which do no strictly speaking, fall in either of the two classes mentioned, an may be modified drift clays.

The descriptions of the individual localities are taken up ge graphically from east to west.

Mira River.—Mira river is a stream emptying into Cow bay Mira station on the Sydney and Louisburg railway. The strea proceeding upward, passes first through a narrow but not deep gor known as Mira Gut, and then broadens out into a lake, containi numerous islands, only to narrow again in a short distance. Borde ing this lake at several points are low hills, which are underlain many places by deposits of laminated clays and sands, evidently estuarine character, and resembling those found in the Annapo valley, although more sandy.

At the time of our visit the deposit was being worked at one poi by the Mira River Brick Company, at a locality about four mi from Mira River station. (Plate XIX.)

The clay bank, which lies to the west of the works, shows at le 25 feet of blue laminated clay, overlain by a somewhat sharply fined layer of yellowish clay, from 2 to 3 feet thick, which is sligh denser and more sandy than the blue.

Topping this is a pebbly sand layer 2 to 8 feet thick, the pebb being of different kinds, but not a few of them representing cr talline rocks. More clay is found at Clay Banks, four miles up river, and at a point about 1½ miles down stream.

In utilizing this clay it is necessary to add about one-third sa to counteract the shrinkage, but unfortunately no attempt is m to screen the sand. The clay is loaded into barrows and whee

PLATE XVI.

Shale beds, red on top and blue below, south of Merritt point.

PLATE XVII.

Continuous kiln under construction, Mira River Brick Co., Cape Breton.

PLATE XVIII.

Clay conveyer, Mira River Brick Works, Mira river, Cape Breton.

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PLATE XIX.

Clay bank, Mira River Brick Works, Cape Breton.

to a belt conveyer, which takes it to the moulding machine. This belt is not run to its full capacity.

The blue clay is said to have a higher shrinkage than the yellow. If the sand were screened, a smoother brick would result, and in many cases also a stronger one.

The clay is moulded in a soft mud machine, dried on pallet racks, and burned in a seven chamber Haigh continuous kiln.

This clay deposit is said to have been first worked about 42 years ago, the first yard being run by a man named Haile, half a mile up stream from the present yard. About 40 years ago Caleb Huntington began manufacturing brick on the site of the present yard.

The bricks are loaded on scows and taken to Glace bay and Sydney.

Tests of the clays follow:—

No. I represents the blue clay; No. II is the yellow clay; No. III is the brick mixture. The three are placed in parallel columns for comparison:—

WET-MOULDED BRICKLETS.

—	I	II	III
Water required	24 %	24·2	21·2
Plasticity	Good.	Slight.	Good.
Air shrinkage	7 %	3·1	6·15
Tensile strength, lbs. per sq. in.	60	Low.	118
Per cent passing 200 mesh	99 %	....	67·6 %
Cone 010—			
Fire shrinkage	-0·8 %	-0·65	0·3
Absorption	19·49 %	20·62	12·45
Colour	Red.	Red.	Red.
Cone 05—			
Fire shrinkage	2	1	4·3
Absorption	15·32	19·98	6·61
Colour	Red.	Red.	Red.
Cone 03—			
Fire shrinkage	4	1·3	5
Absorption	9·37	18·18	1·43
Colour	Red.	....	Chocolate brown.
Cone 1—			
Fire shrinkage	Nearly fused	2	1
Absorption	....	14·06	1·59
Colour	....	Red.	Brown.

I. This clay alone is barely hard enough at 010, but steel ha at 05. It gives a good dry-press at cone 03.

II. This is an exceedingly sandy clay, and too sandy when us alone. It is mixed with the blue clay.

III. This mixture is quite different from the clay alone, and l about 25 per cent of admixed sand. It burns to a good red body 010, and becomes steel hard at 03, but is beyond vitrification at co 1. It gives a good dry-press at 03.

Sydney and Vicinity.—Much of the surface in the Sydney regi is underlain by a yellowish loamy clay, at times more or less pebl in character. Such clays sometimes attain an undeserved reputati as being fireclays, possibly for the reason that they may have be used for patching up stove brick, or a cupola lining.

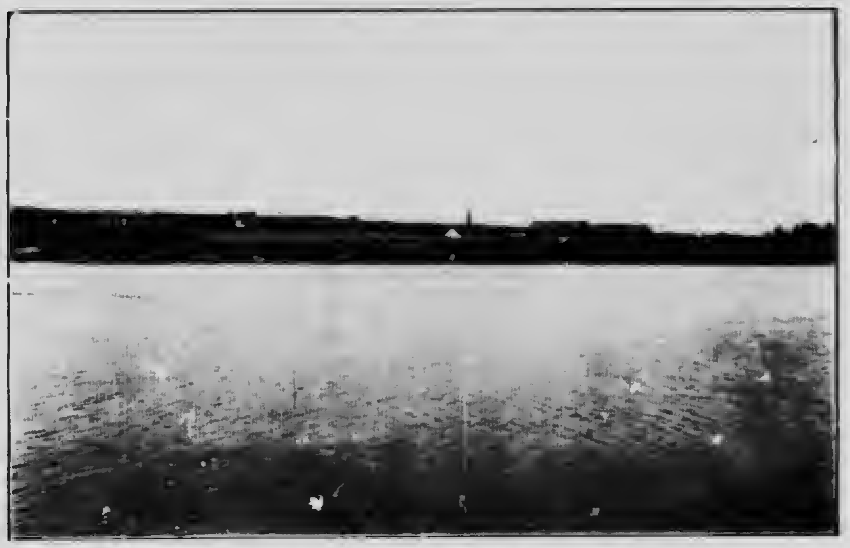
Such a clay, for example, is found in the fields around No colliery of the Nova Scotia Steel and Coal Company. This partic lar deposit is said to be 30 feet thick, and possibly it is, but t material is not a fireclay. It would make good brick.

Clays have also been found and worked for common brick alo George creek and Leitch creek, near their entrance to Sydn harbour. The deposits are usually shallow.

McKinnon Harbour.—There are no brick works or clay pits this vicinity, but there is a somewhat abundant deposit of stiff stony glacial clay, which covers much of the lower lying knolls alo the north side of the Big Bras d'Or lake. This has been well posed in a number of cuts made for the quarry road to the n gypsum quarries west of Ottawa siding. The material could be u for common brick manufacture provided the stones were remov and some sand added to the clay. It is too tough and stony to used alone. The following tests represent its character:—

The clay worked up with 20·8 per cent water to a very stic plastic mass, whose air shrinkage was 7·6 per cent. The aver tensile strength was 222·3 pounds per square inch, and 64·6 per c of the clay passes a 200 mesh sieve.

PLATE XX.



View of brick works at Sylvester, Nova Scotia.

The following results were obtained in the firing tests:—

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·4	14·27	Red.
05	2·6	9·92	Dark red.
03	3	10·19	"
1	3·6	0·94	"
2-3	Fused.		

The clay gave a fairly hard body of good colour at cone 010, and does not darken much up to cone 03.

There are small white specks in some of the bricklets, which are evidently calcined gypsum grains, but these do no harm, as they do not slake as lime grains would.

The material is a common brick clay of good character, but it would require at least one-fifth to one-fourth sand to be added to it.

Baddeck.—This village lies on the shore of Little Bras d'Or lake, about twelve miles northwest of Grand Narrows.

The hills surrounding it are mantled with glacial drift, but there are a few surface deposits of clay, which may be of estuarine character. Their extent and thickness are, however, but imperfectly known, and few of them lie close to the shore.

One in particular which has attracted attention is a blue clay on the property of C. L. Campbell, about one mile northeast of the town. It contains a bronzy material, which was described by Dr. Hoffman as a new mineral species, and called baddeckite.

As is often the case, the clay has been called a fireclay for no apparent reason.

Outcrops of the clay were found in the woods along Miles brook, and about 10 to 20 feet above the stream level. Owing to the limited outcrops, and abundance of slide material, it was impossible to tell anything definite regarding the extent of the material without making a number of borings.

In its field characters the clay is somewhat similar to that worked at Eden Siding, but lacks the numerous stones.

The clay is very smooth and plastic, and of very fine grain, as 94·6 per cent passes a 200 mesh sieve. It worked up with 24·2 per cent water, the resulting mass showing 7 per cent air shrinkage, and an average tensile strength when air dry of 56 pounds per square inch. This was low, similar to that of the Mira River blue clay.

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

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·5	15·06	Pink.
05	4·3	9·81	Light red.
03	5·3	4·30	Red brown.
1	7·6	0·07	Dark brown.
3	Fused.		

The clay is a good brick clay, and might do for common red earthenware.

Eden Siding.—This locality is a flag station on the Intercolonial railway, four miles northeast of River Denys Station. The material is a tough, reddish brown surface clay, presumably of glacial origin, and while it is much freer from stones than the glacial clays usually are, it lacks the laminations so characteristic of the estuarine clays. (Plate XXII.) The clay is used for common brick, and is said to fire crack if used alone. Even with sand added the bricks are more tender than those made from the Shubenacadie clay, and have to be set perfectly dry.

This holds true, it is said, even when 10 per cent of sand is added. A sample of the clay was tested without adding sand, and yielded the following results:—

Water required for mixing, 25 per cent; plasticity, high; average tensile strength, 230·2 pounds per square inch; amount passing through 200 mesh sieve, 88 per cent.

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	1·5	16·24	Red.
05	4·3	9·85	Dark red.
03	5·0	7·62	" "
1	Fused.		

PLATE XXI.

Miller Bros'. brickyard, Eden siding, Cape Breton.

PLATE XXII.

Clay pit at Miller Bros'. brickyard, Eden siding, Cape Breton.

The bricklets have a good colour and ring at 010 and are steel hard at 05. A good dry-press bricklet was obtained at cone 03, which had 9·16 per cent absorption.

Diogenes Brook.—Considerable attention has been drawn to certain deposits of Pleistocene clay found on Diogenes brook, and some rather exaggerated statements have been made regarding their extent and value. In order to confirm or contradict the statements which have been somewhat widely spread, the locality was visited by Mr. Keele, and his notes are given below. These show that the clays do not possess the market value which has been assigned to them by some persons.

Mr. Keele's notes follow:—

"A deposit of white clay is found near the headwaters of Diogenes brook, one of the tributaries of Denys river. This brook cuts through the eastern flanks of the Craignish hills, which form the western border of a wide valley across which Denys river flows.

"The clay is at present only exposed at one point on the brook, at a short distance below a small fork that comes in from the west. A few years ago a quantity of the clay was shipped, but the openings made then are now concealed by gravel slides.

"The portion of the brook where the clay occurs is situated in a narrow gorge of steep grade, sunk to a depth of about 250 feet below the level of the upland. A road was built down the brook, leading to the open valley below, in order to haul the clay to River Denys Station, the nearest point on the Intercolonial railway, a distance of nine miles. The bottom of the gorge is so narrow that there is scarcely room for both the road and the brook.

"Borings made on the clay were said to have revealed a sufficient thickness to form a workable deposit, but that the clay was interstratified by sandy layers. The deposit, however, appears to be of limited width, as rim rock crops out at several points along the gorge. Any attempt to mine the clay on a large scale is liable to serious interruption by landslides from the glacial drift, which clings in large masses to the steep slopes.

"Both the valley bottom and the slopes of the gorge are now heavily timbered, which serves to hold the loose material in place.

"At the forks of the stream, at the upper end of the clay deposit, is a considerable thickness of white clayey sand, from which the white clay appears to have been derived by the washing of the brook. The white sand appears to be preglacial, and is probably derived from the breaking down of the igneous rocks which form the upland. The principal rocks are felsite, syenite, and sericite schist, judging by the wash in the brook. A short distance below the white clay a mottled red and dark blue clay is exposed on the brook side. A similar clay is found widespread in the valley through which the Denys river meanders, and is worked for brick making at Eden Siding on the Intercolonial railway. This clay overlies the glacial drift in the valley, and may be a lake or estuarine clay. If so, it would indicate a greater submergence of the land than has been supposed for this region. Tests of these are given in the table, Appendix I.

"*Town of Antigonish.*—Three brickyards were in operation in the vicinity of the town of Antigonish a few years ago, making soft mud bricks, principally for the local market. Two of these yards obtained their material from the intervale land, lying along the river banks. Here a flood-plain clay is found, about 4 feet thick, and carrying the proper proportion of sand for bricks. Owing to the scarcity of labour, and the low price obtained for brick, none of these yards are now in operation."

Sylvester.—A plant has been established at this locality by the Sylvester Brick and Tile Company, to utilize a somewhat stony, gritty, glacial clay lying about half a mile south of the railway station. The material is so stony, however, that its use does not seem to have met with much success, although considerable money was evidently expended on the plant. It was not in operation in the summer of 1909, but is said to have been running for a short time in the spring of that year.

"*Parrsboro and vicinity.*[1]—A deposit of highly plastic red clay occurs on the shore about half a mile beyond the Government wharf. This clay is laminated with thin sandy partings, and is similar to that found in the Annapolis valley, where it is worked into brick and drain tile. The clay is exposed in a bank along the shore, in a bed from 3 to 5 feet thick, overlying boulder clay, and covered by stratified sand and gravel, which varies in thickness from a few inches to several feet. This clay is again seen at the mouth of Swan creek about five miles east of Parrsboro, where a small quantity of bricks

[1] Notes by J. Keele.

were made about fifty years ago. The thickest deposit of this clay occurs at Whitehall creek, about one mile south of Parrsboro, and bricks were made at this point about 20 years ago by Mr. John Manning. During the rebuilding of St. John, after the great fire, a schooner load of bricks was sent to that city from his yard.

"This plastic red surface clay probably extends for some distance up the valley of Parrsboro river. No bricks are manufactured in this neighbourhood at present.

Shubenacadie valley.—During the glacial period a considerable quantity of glacial drift, much of it of gravelly, stratified character, was deposited in the Shubenacadie valley. Subsequent to this there was a submergence of the land, to at least 75 feet below the present level, during which the sea entered the Shubenacadie and Annapolis valleys, converting them into arms of the sea.

It was at this time that much fine clay and sand were laid down on the uneven surface of glacial drift which floored these valleys. A subsequent re-elevation of the land caused the streams occupying these valleys to erode some of these clays, but much of it has been left, and is now found underlying the flood-plain terraces on either side of the river.

It will be easily understood that the depth of these estuarine clays must be variable, because of the uneven surface of the underlying drift. Indeed, in some cases the drift rises close to the surface of the intervale, or sometimes extends above it.

Along the Shubenacadie river, which rises near Halifax, and flows in general northward, into Cobequid bay, the estuarine clays are found at a number of points, and are worked at several localities as described below.

Elmsdale.—The clay deposit worked by the Elmsdale Brick and Tile Company lies near Charley brook, a branch of the Shubenacadie river. It underlies the flat lands bordering the river, and is of uneven depth, ranging from 4 to 20 feet, with gravel underneath, and an occasional thin covering of sand on top. The top clay is of a greyish colour, and the underlying material reddish brown.

The following tests give the properties of, (1) the clay, and (2) the clay with one-quarter sand added:—

WET-MOULDED BRICKLETS.

——	1	2
Water required	30·5 %	23·8 %
Average tensile strength	143 lbs.	140 lbs.
Per cent passing 200 mesh	90·6 %	70·6 %
Air shrinkage	6·3 %	7·3 %
Cone 010—		
Fire shrinkage	4 %	1·6 %
Colour	Red.	Red.
Absorption	13·6 %	8 54 %
Cone 05—		
Fire shrinkage	9·6 %	6·0 %
Colour	Red brown.	Red brown.
Absorption	2·22 %	4·23 %
Cone 03—		
Fire shrinkage	4 %	7·0 %
Colour	Red brown.	Red brown.
Absorption	0	1·14 %
Cone 1—		
Fire shrinkage	Melted.	Nearly fused.

No. 1 burns to a hard body at 010, but shows a tendency to warp, and shrinks too much at that cone. It is very plastic, and does not work well alone wet-moulded, but works all right when dry-pressed. This clay can also be used for drain tile.

No. 2 represents the green-brick mixture, that is, No. 1, with about 25 per cent sand added. The addition of the sand reduces the air and fire shrinkage, as comparison of the two sets of tests given above will show. A good body for common brick is obtained at cone 010, and a good dry-press at 05, although at this last cone the colour deepens considerably.

Enfield.—Clay is known to occur at a number of points bordering the Shubenacadie river, from Shubenacadie to Enfield. Between Enfield and Elmsdale, the material is variable in its character, and some of it is quite smooth and plastic enough for making pottery. Near Preston's pottery, 1½ miles south of Elmsdale, the clay is to be found at a number of points in the flood-plain bordering the river, but its thickness is not great, ranging from 3 to 15 feet, and underlain by gravel. Going away from the river the clay thins out.

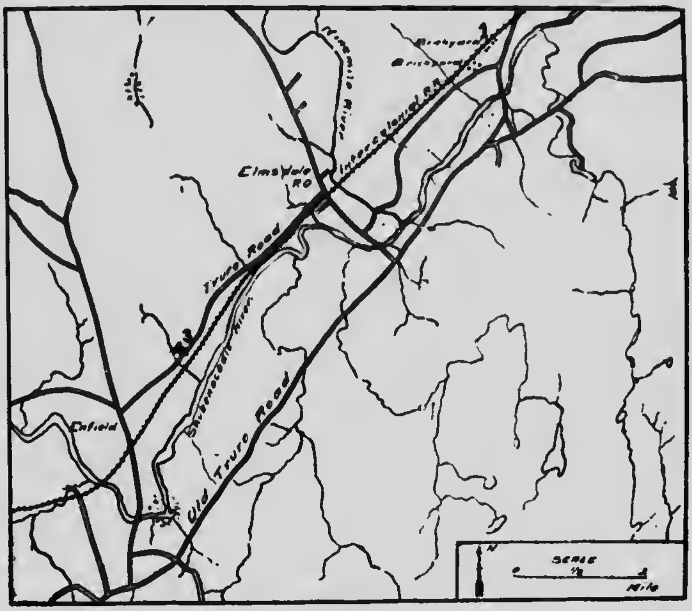


Fig. 13.—Map of the valley of the Shubenacadie, between Enfield and Elmsdale.

The clay in its general properties is somewhat similar to that worked at the brick-yard above Elmsdale, but it is less sandy.

The clay used for this purpose represents one of the finer grained and more plastic phases of the estuarine clays found bordering the Shubenacadie river.

It is an exceedingly plastic and smooth material that required 30 per cent of water to work it up for moulding. In spite of its apparent smoothness and fineness so far as one could judge from the feel, only 70 per cent passed a 200 mesh sieve.

The average tensile strength is 226 pounds per square inch, and the air shrinkage 8·3 per cent.

The clay behaved as follows in burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	1·3	11·81	Red.
05	7·6	0·20	Red brown.
03	8·3	0·027	Red brown.
1	Fused.		

The clay burns to a dense hard body at 010, and is steel hard at 05. It made an excellent dry-pressed body at 03.

In some pits dug by the pottery makers there is a lower red clay, which differs somewhat from the blue in having higher fire shrinkage, as shown by the following tests:—

Water required, 31·6 per cent; per cent passing 200 mesh sieve, 89·2; average tensile strength, 194 pounds per square inch; air shrinkage, 9·2 per cent.

In burning, the wet-moulded bricklets behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	2·4	14·69	Red.
05	8	0·42	Dark red.
03	9·3	0·00	Red brown.
1	Nearly fused.		

The clay burns to a good hard body, but is not steel hard until cone 05. A dry-press bricklet burned to cone 03 had a good hard ring, but the colour was not very bright.

Shubenacadie.—About two miles north of Shubenacadie the Pleistocene clays are opened up for brick making.

The clay is evidently of estuarine character, and while its general surface is not much above that of the plain bordering the river, its bottom seems to be somewhat irregular. The deposit is also surrounded in part by hillocks underlain by glacial drift.

Since this clay is post glacial it must, therefore, have been deposited here on the uneven surface of the drift.

The estuarine clay, or that used for brick manufacture, is as much as 25 feet thick and is underlain by gravelly glacial clay. It is mostly reddish brown, with bluish streaks, and there is a blue clay at the bottom which carries a high percentage of soluble salts, which come out strongly, if any of this clay is used.

Annapolis Valley Region.—From Wolfville to Annapolis bay there is a valley bounded by the Silurian ridge on the southeast and the hills of Triassic rock on the northwest. The bottom of this depression is flat, or very gently rolling, and the surface formation is usually a stratified sand, which is underlain by estuarine clays. At many points these are found close to the surface, with little or no sand covering. They are underlain in turn by glacial drift.

How continuous these estuarine clay deposits are it is not possible to say, but the fact that they occur at a number of points from Avonport to Digby indicates that they must be rather wide-spread. This is not surprising, since the floor of the valley must have been flooded during the post-glacial submergence. We have no records, however, showing that the deposits are of great thickness; and that this is often improbable is shown by the fact that in all the clay pits glacial drift is encountered at no great depth.

At present these clays are opened up for working at Avonport, Middleton, and Annapolis Royal. Another deposit, not being worked at present, is located at Bridgetown, south of Middleton.

The character of the deposits at several of these localities is given below.

Avonport.—A laminated clay, with sandy laminæ more numerous in the upper portion, is opened up near Shaw's brickyard. (Plate XXIV.)

The average thickness is 9 to 10 feet, but it may reach 25 feet in places. There is a thin bed of capping sand, but the two are not always sharply separated, and the sand where differentiable is not over 2 feet thick. The lower beds in the pit are more plastic, and the clay rests on a so-called hardpan.

The following tests indicate the character of the clay:—

Clay fine-grained, 96 per cent passing through a 200 mesh sieve. It worked up with 25·6 per cent water to a very smooth and plastic mass, whose air shrinkage was 7·2 per cent, and average tensile strength 145 pounds per square inch.

The wet-moulded bricklets behaved as follows in burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	2·2	11·36	Red.
05	5	6·43	Red.
03	6	2·96	Red brown
1	Fused.		

The clay gives a good body and colour at cone 010, which it holds up to 03. A good dry-press bricklet, with 6·43 per cent absorption was obtained at 03.

This makes a good common brick at 010, and could also be used for drain tile.

Middleton.—The town lies on a flat sand-plain, which is underlain by a laminated, at times silty clay, known to be from 5 to 10 feet in thickness in the brick-yard pit, but said to be over 100 feet thick in some of the well borings around town. The material is probably an estuarine clay, deposited in a basin in the stony glacial clay. The latter is found in the field to the west of the brick-yard, and the same material is found underlying the stratified brick clay at the yard, at a depth in places of not more than 6 feet.

The qualities of the brick clay are given below, these determinations being made on a sample cut from the top to the bottom of the working face.

The addition of 21 per cent of water to the dry clay gave a very plastic mass, with an air shrinkage of 7 per cent.

At cone 010 the fire shrinkage is 0·3 per cent, absorption 21·36, and colour red.

At cone 03 the fire shrinkage is 2 per cent, absorption 13·31 per cent, and colour the same.

A saleable brick is obtained even at cone 010, although the absorption is rather high.

This material makes an excellent common brick, while the more plastic smoother portions are also employed for drain tile. The latter can also, without washing, be used for making the cheaper kinds of art pottery and art tiles.

PLATE XXIII.

Robert Shaw's brick works, Avonport, Nova Scotia.

PLATE XXIV.

Clay bank, showing laminations, Avonport, Nova Scotia.

PLATE XXV.

Plant of Buckler Brick Co., Annapolis Royal, Nova Scotia.

PLATE XXVI.

Clay pit Buckler Brick Co. Annapolis Royal, Nova Scotia

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Annapolis Royal.—A small area of estuarine clay is being utilized by the Buckler Brick Company, southeast of the town. (Plate XXVI.)

The deposit is claimed to have a depth of 20 feet, and is underlain by gravel or boulder clay, and covered by 1 to 2 feet of sand, the latter usually sharply separated from the former.

The clay whose properties are given below is less strongly laminated than that at Avonport and Middleton, but appears to be tougher.

The lowest beds in the bank evidently contain an appreciable quantity of soluble salts, for they whitewash badly if it is used.

The clay deposit does not appear to rise much more than 30 feet above the shore line of Annapolis bay.

Tests on the Buckler clay gave an air shrinkage of 7·2 per cent. At cone 010 it had shrunk 1·3 per cent, and absorbed 13·41 per cent. At cone 03 the fire shrinkage was 5·3 per cent, and absorption 5·85 per cent. It burns to a good red colour and body at 010, but does not become steel hard until cone 03. The clay is adapted to the manufacture of common brick, and it is probable that the smoother and more plastic portions of it could be used for making drain tile, and common red earthenware.

Yarmouth.—We were informed that a pottery was at one time in operation at this locality, but were unable to find any trace of it, and the rumour probably had no foundation. Indeed, aside from bare rock, the only surface formation is boulder drift.

zoic.

CLAYS IN MUSQUODOBOIT VALLEY AT SHUBENACADIE.

A most remarkable clay, and one of undetermined age, is that found in the Musquodoboit valley, and at Shubenacadie. The material is a highly plastic clay, of dark grey, white, or mottled red and white colour, lying beneath glacial drift, and resting probably on bed-rock.

Scattered lumps of lignite were found in the clay at both localities, and it is hoped that the age of these can be determined.

It is exceedingly difficult to [illegible]ine the exact area underlain by this deposit, owing to the heavy mantle of glacial drift overlying this region, but the fact that the material is found at several points, extending over a distance of seven miles, indicates its probable extent, unless some of the masses have been pushed along with the drift. Borings could, of course, only be made at those points where the drift cover was thin, or absent.

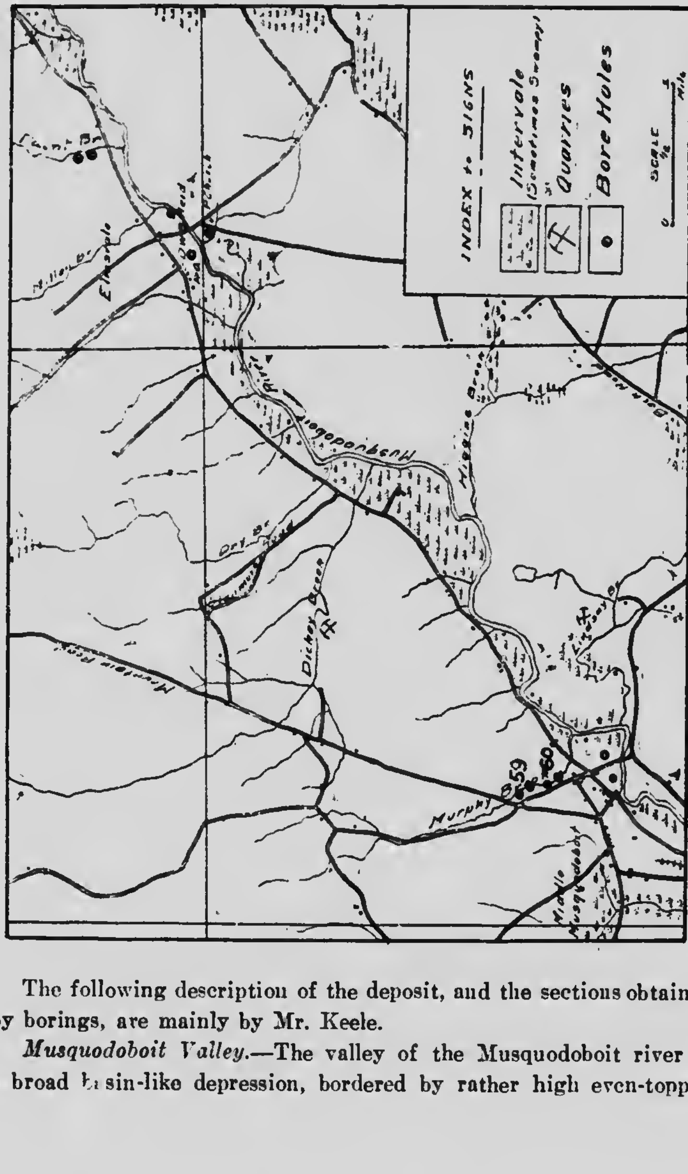

FIG. 14.—Map of a portion of the valley of the Musquodoboit river.

The following description of the deposit, and the sections obtained by borings, are mainly by Mr. Keele.

Musquodoboit Valley.—The valley of the Musquodoboit river is a broad basin-like depression, bordered by rather high even-topped ridges with gentle side slopes. The valley is floored with glacial drift, which overlies unconsolidated sediments of unknown depth, and is here referred to as the 'underclay.' The river at present flows with a meandering course, in a wide trench cut through the glacial drift, and at some points has sunk its bed below the surface of the underclay.

The intervale, or flood-plain of the river, averages less than half a mile in width, and is generally fertile meadow land.

The underclay outcrops at a few points along the banks of the river at the village of Middle Musquodoboit and for several miles above, and on Murphy brook, and Paint brook, two small streams entering from the north.

By reason of its bright colours and high plasticity, the underclay has attracted the attention of the inhabitants along the valley for many years. Samples of the clay have been taken out at various times for the purpose of testing its quality, but no definite result as to its uses, or concerning the character of the deposit, has been hitherto available.

A small portion of this deposit was examined in 1900 by Mr. F. H. Mason, of Halifax, his operations being confined to a part of Murphy brook at Middle Musquodoboit. The results of his investigation were given in a paper read before the Nova Scotia Mining Institute, in 1901. He was in search of a highly refractory material to use in the manufacture of firebrick, and did not test the clay for any other purpose.

The underclay was laid down previous to the glaciation of the region and consequently has suffered much from erosion during that period. The glacial drift—principally a stiff boulder clay—covers the underclay for the most part with a thick mantle. The matrix of the boulder clay contains a fairly large proportion of the underclay thoroughly mixed with ordinary glacial clay, but occasional large patches of the underclay were floated off and incorporated in the drift. The underclay is rarely seen, as, owing to its highly plastic nature, it flows easily, when exposed by river erosion to a vertical face, thereby causing the collapse of the overlying drift, which effectually buries it again.

The limited number of borings made revealed the fact that there is not a mass of pure high grade clay, such as is generally alleged in the neighbourhood, but that the occurrence is a stratified deposit made up of alternating beds of clays, silts, and sands, with occasional layers of lignite, and some concretionary iron pyrite.

The sections obtained show considerable variation in the sequence and thickness of the beds, even within short distances, which would indicate that the deposit is irregular in its horizontal, as well as in its vertical distribution.

The prevailing colour of the clay is mottled grey and red: this grades into beds of a solid grey colour, either dark or light shades, and is generally considered the most desirable portion of the deposit; or into beds of a solid red colour, which contain too high a percentage of iron, and are, therefore, undesirable. On a short exposure to weathering all the colours bleach considerably, the dark or lead-coloured clay becomes light grey, the light grey becomes white, and the red a salmon colour.

The materials composing the clays are, as a rule, in an exceedingly finely divided state.

The character of the deposit would indicate that the sediments composing it were laid down during the occupation of the valley by a shallow body of still water, possibly an arm of the sea. The clays may have been transported for long distances, probably from the granite areas eastward of the headwaters of the present river, which were then highlands and subject to decomposition and erosion. During periods of flood, sands, silts, and floodwood were washed in from the surrounding hills and carried out to various distances from the shores, and deposited as impurities with the transported clays. Most of the iron oxide distributed through the beds was probably derived from the ferruginous slates, which form the bed-rock of the ridge bordering the valley to the north.

Borings were attempted at a number of points in the vicinity of Elmsvale, but owing to the bouldery character of the glacial overburden, and the short time devoted to the investigation, very few of the boreholes succeeded in reaching the underclay.

The best section in this locality was obtained at Paint brook, where this stream has worn down to the underclay. Here a considerable body of plastic clay, with only a very slight proportion of sand, was revealed by the borings. Unfortunately this clay carries more iron than was found at any other locality, the upper beds having a solid bright red colour. This portion of the deposit has been used to some extent as a paint for barns and outbuildings in the valley. The clay here, as well as in all the borings published, is of unknown depth, the holes going to the depth limited by the apparatus used, but in most cases they were carried only far enough to prove a workable deposit. The clay has been exposed for years on the river bank about half a mile above Paint brook, where the river swings close against the road. A good deal of clay was taken from this point, but operations were stopped on account of the sliding of the overburden, and caving of the roadway. This outcrop is now completely concealed.

No clay is reported to have been seen in the valley above this point, and no borings were made above Paint brook by the writer.

On the south bank of the river, about a quarter of a mile above the bridge, there is a good exposure of the clay, seen best at low water. The south bank rises rather steeply, and the overburden here is very thick, being from 20 to 40 feet.

A number of years ago a boring was made for coal at this point, and a depth of 205 feet was reached, which was said to be all in clay. Mr. Millen, who assisted at the drill, informed the writer that at a depth of 65 feet they went through a bed of black clay, which was about 10 feet thick; and at 138 feet deep a similar bed, carrying float coal, and 15 or 20 feet thick, was pierced.

BORINGS FOR CLAY NEAR ELMSVALE.

On property of Norman Deal, west bank of Paint brook—

	Ft.	Ins.
Soil	1	0
Bright red clay	8	0
Mottled red and grey clay	3	0
Grey sand	1	0
Mottled red and grey clay	8	0
Coarse dark red sand	0	6
Mottled red and grey clay	3	6
	25	0

On Paint brook—75 feet higher up stream—

	Ft.	Ins.
Soil and gravel	3	6
Mottled red and grey clay	4	6
Light grey clay	2	0
Mottled grey and red clay	5	0
Dark grey clay	1	6
Mottled red and grey clay	1	6
	18	0

On road near Presbyterian church, patch of clay exposed on roadside—

	Ft.	Ins.
Light grey clay	1	0
Coarse brown sand	4	0
Light grey clay	6	6
Yellow sandy clay	0	6
Mottled red and grey clay	3	0
Red and grey stratified sand with some thin layers of clay.	6	0
Mottled red and grey clay	1	0
Light grey sand	3	0
	19	0

In field on intervale, property of D. W. B. Reid, about 500 feet west of church—

	Ft.	Ins.
Soil and glacial clay with pebbles	11	0
Mottled red and grey clay	5	0

Loose pebbles from side of borehole jammed the auger and prevented further boring at this point.

A small quantity of the underclay has been mined and sent abroad from Murphy brook at Middle Musquodoboit, where the clay may be seen at two or three places in the brook.

The sections here show a rather good body and quality of clay on the lower portion of the brook, near Mr. G. T. Reid's house, the clay being at least 17 to 20 feet thick, beginning at the surface, and containing no sandy partings. At a short distance from the edge of the creek in this vicinity, the overburden becomes heavy, particularly on the east side, where there is a gravel terrace about 20 feet high.

Although good beds of clay were found in the upper portion of the brook, they were of no great thickness; and being interstratified with sand and silt could scarcely be economically worked, as far as the area examined is concerned.

A boring made almost at water level on the bank of the river, about one-eighth of a mile above Murphy brook, and situated on Mr. Wm. McCurdy's property, showed at least 23 feet of clay and silt. This section, taken in conjunction with that obtained at the higher elevation on Murphy brook, would give a thickness of at least 50 feet of underclay, on the assumption that the beds are flat lying, which they appear to be.

BORINGS IN CLAY AT MIDDLE MUSQUODOBOIT.

Borehole No. 1—Murphy brook, about 225 feet above G. T. Reid's house (clay exposed in bed of brook)—

	Ft.	Ins.
Grey clay, with some mottled red and grey beds	17	0
Silty clay	4	0
Mottled red and grey clay	1	0
	22	0

Borehole No. 2—Murphy brook, about 400 feet above No. 1 (clay exposed at edge of brook)—

	Ft.	Ins.
Mottled red and grey clay	20	0
Dark grey clay, sand and lignite	1	6
Dark grey clay	2	0
Mottled red and grey clay	1	6
	25	0

Borehole No. 3—Murphy brook, on west bank, 30 feet from brook, about 250 feet above No. 2—

	Ft.	Ins.
Soil	1	0
Mottled red and grey clay	1	0
Glacial clay	5	0
Dark grey clay	1	0
Red and grey mottled clay	1	0
Light grey clay	2	0
Red and grey mottled clay	1	0
Grey sandy clay	1	0
Red sand	1	0
White sand—water	2	0
	16	0

Borehole No. 4—Murphy brook, about 250 feet above No. 3 (clay exposed on bank)—

	Ft.	Ins.
Light grey clay	3	0
Mottled red and grey clay	2	0
" " silty clay	4	0
Yellow, white, and grey stratified sands	9	0
	18	0

Borehole No. 5—On William McCurdy's property (clay exposed at edge of Musquodoboit river)—

	Ft.	Ins.
Mottled white and red clay	1	0
Grey clay	3	0
Mottled red and grey clay	8	0
Red and grey silty clay	3	0
Grey clay	4	0
Brown and grey silty clay	3	0
Grey and mottled clay	1	0
	23	0

Borehole No. 6—On William Sedgewick's property at edge of terrace, 20 feet above river level—

	Ft.	Ins.
Red clay	2	0
Light grey clay and silt	2	0
Brownish clay	2	0
" silt	1	0
Red sandy clay	0	6
Reddish sand	0	6
Light brown silt	1	0
Dark grey sand with lignite	0	6
" clay	4	6
" sand with lignite	1	0
White clay	2	0
Reddish sand	1	0
Mottled red and grey clay	1	6
White sand	0	6
Mottled red and grey silty clay	2	0
	22	0

Some of the borings made by Mr. Mason, on Murphy brook, resulted as follows: The first borehole showed 4'-6" of white clay, then 2 feet of micaceous sand, in which occurred fair sized pieces of iron pyrites, then 11'-6" of mottled clay. The next hole, some 600 feet higher up stream, gave 6 feet of white clay, followed by 12 feet of mottled clay. Another hole, 100 feet away from the last, gave 1 foot white, 7 feet mottled, then 17 feet of white, and another hole gave 7 feet of surface alluvium, and 22 feet of white clay. Several other boreholes were put down and some shafts sunk, but the details were not given. He states that there is undoubtedly a large body of clay at this point, but the general results are disappointing, as the clay contains too much iron to be of any use as a fireclay. Mr. Mason had some of the clay made up into bricks, containing 25 per cent of silica sand. These were subjected to the heat of the blast furnace, with the result that they were cut up in 24 hours.

The deposit is unquestionably an extensive one, probably covering several square miles in superficial area. A complete vertical section would be extremely interesting, from a scientific point of view at any rate, but it is unlikely that clay prospectors will bore so deeply.

In prospecting for workable deposits of this clay it is advisable to make several borings in order to locate the best material and the amount of covering upon it. The surface of the ground forms no clue to the depth at which the underclay will be found, as the upper surface of the underclay is undulating, owing to uneven glacial scouring, and at some places comes quite close to the surface, while at other places it may be too deeply buried to be economically worked.

Owing to the shifting character of the sediments the individual beds are often of very slight lateral extent, so that a good bed of clay suitable for some of the better grades of pottery ware may be found to pinch out, or become too sandy, or carry too much iron within narrow limits.

The plasticity of the clay is generally good, even the silty beds possess fair plasticity, and as the shrinkage of the latter is less than in the purer beds, they may be manufactured into the higher grades of structural material, such as pressed brick and floor tiles.

Along the strip of intervale, and generally close to the river, are some large patches of very stiff and very adhesive clay of light grey or bluish colour. The searcher for clay is likely to be referred to these localities by the inhabitants, but they are of no importance, being usually about a foot in thickness, and representing sediment deposited in time of flood.

The only means of transportation in the region is by wagon. The road followed in going to market from Middle Musquodoboit leads to Shubenacadie on the Intercolonial railway, a distance of about eighteen miles. This road traverses an undulating, well wooded, but otherwise rather barren country, and is poorly maintained.

The physical tests of the clay, and chemical composition, are given below.

The red and grey mottled clay is from outcrop on Murphy brook, at borehole No. 2.

This is a very fine-grained clay, as 91·6 per cent passed through a 200 mesh sieve. It worked up with 30·8 per cent water to a very smooth plastic mass, the air shrinkage of which was 6·5 per cent, and average tensile strength 68 pounds per square inch. The clay showed a tendency to warp in air drying.

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·1	21·68	Salmon pink.
05	2·6	18·29	Light salmon pink
03	6	12·96	" "
1	6·3	7·00	Pink.
[illegible]	6·3	5·41	Pink.
[illegible]	7·3	3·66	Red.
9	9	0·29	Red brown.

The bricklets had a good body at 05, and were steel hard at 03. They preserved their form at 9, but the shrinkage was rather high.

The clay gave a good dry press body at cone 03.

Another sample represents the light grey clay from the opening farthest up Murphy brook.

This was also very smooth and plastic, and 99 per cent of it passed through a 200 mesh sieve.

The clay had an air shrinkage of 6·8 per cent, and an average tensile strength of 81 pounds per square inch.

It behaved as follows in burning:—

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·4	19·3	White.
05	2·3	16·71	"
03	6·0	15·92	"
1	6·0	7·41	"
3	7·0	7·71	Cream.
5	7·3	4·89	"
9	8·0	4·34	"

The bricklets were somewhat soft at cone 010, and fairly hard at 05, but did not become steel hard until cone 1, at which cone the body is very dense, like that of a stoneware clay. The colour did not deepen until cone 9. The clay fuses at cone 27. It may, therefore, be classed as a No. 2 fireclay, and could be used in the manufacture of stoneware, face brick, or terra-cotta. It burns rather dense for a firebrick, and if used for making these, some grog would have to be added.

The following chemical analysis of this clay was made by M. F. Connor, of the Laboratory of the Mines Branch:—

Silica	55·14
Alumina	28·84
Ferric oxide	1·91
Titanic oxide	2·37
Magnesia	0·25
Lime	0·38
Soda	0·48
Potash	1·88
Water	9·24
	100·49

ANALYSIS OF CLAYS FROM MURPHY BROOK.[1]

Analyses of the borings were made by cutting V shaped pieces out of each section of the core, giving the following results:—

	Average sample white clay from 18 ft. bore-hole.	Average sample mottled clay from 15 ft. bore-hole.	Floated mottled clay.	Floated white clay.
Silica	53·20	63·91	52·90	53·00
Alumina	30·25	18·60	29·00	32·10
Oxide of iron	1·72	5·75	3·20	1·70
Lime	nil	trace	*	nil
Magnesia	trace	trace	*	trace
Alkalies	1·33	*	*	0·97
Loss on ignition	12·00	10·30	12·10	12·20
Titanic oxide	1·47	*	*	*

*Not determined.

Shubenacadie.—A light grey coloured plastic clay is exposed beside the Intercolonial Railway tracks, about three-quarters of a mile south of Shubenacadie station.

Small quantities of this clay were mined several years ago and shipped to the Enfield pottery, where a coarse stoneware was manufactured from it.

Lately, an effort was made to place the clay again on the market, and a shaft was sunk by Mr. E. Thompson on his property adjoining the railway track, and not far from the original exposure. This shaft is about 30 feet deep, and penetrates marine and boulder clay for 20 feet, and grey clay for a depth of 10 feet. About 7 feet of clay is exposed in the face of three short drifts leading from the shaft. A boring made by the auger in the bottom of this shaft showed an additional depth of 16 feet of grey clay of a rather silty character. Further boring in the shaft was stopped by the auger striking a stone which could not be penetrated, but whether a boulder or bed-rock is unknown.

A number of borings were made at various points around the village of Shubenacadie. The most of these borings did not reach the grey clay on account of the bouldery nature of the overburden. From the evidence obtained, and the information given by well borers, it appears quite probable that the greater part of the ground occupied by the village of Shubenacadie is underlain by this clay.

[1] Analysis by Mr. F. H. Mason.

The grey clay was deposited previous to the glaciation of the region, and has suffered much from ice erosion, so that its upper surface is very uneven; consequently the depths at which it may be struck below the ground will be very irregular, even where the present sur-

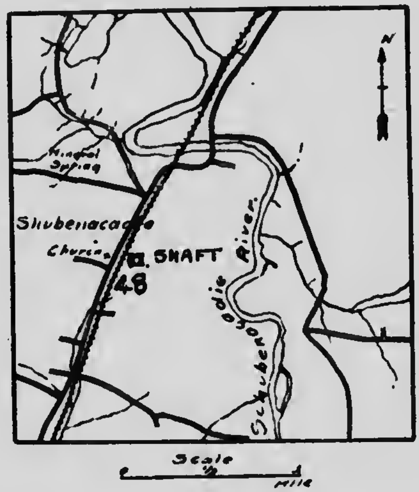

FIG. 15.—Map of Shubenacadie, showing location of shaft in fireclay.

face is fairly level. For example, while the clay lies at a depth of 20 feet below the ground in the shaft, at a point about 350 feet north of this, in Ettars field, the clay comes almost to the surface. At 150 feet farther north the boring did not reveal the clay at 10 feet deep.

The boring in Ettars field revealed the following section:—

BORING IN J. A. ETTAR'S FIELD.

	Ft.	Ins.
Soil	0	6
Grey clay with silt and sand layers	4	6
Grey clay	3	0
Black clay with lignite	0	6
Grey clay	5	0
Sand	0	6
Black clay with lignite	3	0
Grey sandy clay	2	0
Compact grey sand (not penetrated)	-	-
	19	0

PLATE XXVII.

Prescott's Pottery, between Elmsdale and Enfield, Nova Scotia.

PLATE XXVIII.

General view of Millet's brickyard, Elmsdale, Nova Scotia.

BORING NEAR KILPATRICK SIDING.

	Ft.	Ins.
Soil	1	0
Grey sandy clay with lignite	6	0
Black clay with lignite and sandy partings	3	0
Coarse grey sand (not penetrated)	4	0
	14	0

BORING ON MR. DEWIS' PROPERTY.

	Ft.	Ins.
Drift (principally glacial clay containing pebbles)	9	6
Light grey clay	5	0
Sandy clay	1	6
Compact sand (not penetrated)	-	-
	16	0

ON PROPERTY OF MR. M. ANTHONY.

	Ft.	Ins.
Drift (principally pebbly glacial clay)	10	0
Light grey clay (not penetrated, owing to pebbles in overlying drift which jammed the auger)	1	0

A partial test of the dark clay from the shaft at Shubenacadie, shows it to be a very smooth, plastic clay, that works up with 24 per cent water. Its air shrinkage is 7 per cent. It burns white up to cone 1, and its fire shrinkage at cone 010 and 1 is 0 and 5·4 per cent, while the absorption at these two cones is 20·19 and 10·17 per cent respectively. It is steel hard at cone 1.

A small sample of light clay from the shaft was also tested, with the following results.

Like the preceding, this is a very smooth and plastic clay, the air shrinkage of which is 5·8 per cent. In burning it behaved as follows:—

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	-0·6	14·23	White.
05	0·6	13·46	"
03	2	11·00	"
1	2	10·74	"
3	2	10·64	"
5	2	10·04	Cream white.

The clay is nearly steel hard at cone 03. It does not burn dense enough for stoneware, but tests made on a larger sample show that it is sufficiently refractory for firebrick, and could be used for pressed brick, and terra-cotta.

The shaft shows at least 7 feet of clay, mostly of light colour, with layers and wedges of the dark clay.

Near the floor of the drifts the clay is sandy, and contains pyrite concretions which have formed around the sand.

The Intercolonial Coal Company had a number of borings made in the lot in which the shaft is sunk. Most of these were bored under rising ground, where the drift overburden increases, so that only red gravelly clay was encountered. No borings were made on the north side of the ridge. A laminated clay, evidently of estuarine origin, overlies the glacial material in the holes indicated.

FIRECLAY FROM SHUBENACADIE.

The tests were made on a sample taken from a carload lot dug out of the shaft near Shubenacadie.

The clay, of which 74 per cent passed through a 200 mesh sieve, worked up with 22 per cent of water to a very plastic mass, the air shrinkage of which was 6·3 per cent. The average tensile strength was 110 pounds per square inch.

In burning it behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·0	14·9	White.
05	0·6	13·9	"
03	1·6	12·05	"
1	2·0	9·95	Cream.
3	3·0	9·1	Buff.
5	3·0	9·0	"
9	4·0	4·41	Spotted buff.
30	Fused.		

The clay is not very hard at cone 010, but gives a good body at cone 03. The fire shrinkage is low, and it is somewhat dense-burning. It could be used for firebrick, provided some grog was added. The material could, I believe, also be employed in the manufacture of pressed brick, terra-cotta, and stove linings.

Analysis of clay from shaft at Shubenacadie, by M. F. Connor, of the Laboratory of the Mines Branch:—

Silica	74·03
Alumina	17·30
Ferric oxide	1·15
Titanic oxide	1·04
Magnesia	0·16
Lime	0·38
Soda	0·53
Potash	0·88
Water	4·78
	100·25

AGE OF THE SHUBENACADIE FIRECLAYS.

It required only a hasty examination to convince us that the fireclay found near Shubenacadie, and in the Musquodoboit valley, was quite different from any other found in Nova Scotia. It is evidently of pre-glacial age, because it underlies the drift. Its lithological character is so unique as to reasonably preclude its belonging to any of the geological formations of pre-Pleistocene age hitherto recognized in the Province. It bears a striking similarity to the lower Cretaceous clays found in New Jersey, and like them contains lignite. No other organic remains were found in the clay, and for the present the determination of its age must rest on the identification of the wood of the lignite, if this is possible. For these reasons the clay is tentatively classed as Mesozoic.

CHAPTER III.

NEW BRUNSWICK.

Lower Carboniferous.

As most of the field season was spent in Nova Scotia, little time remained for investigation in New Brunswick. Several areas were, however, visited, and some preliminary notes regarding them are here presented, the localities being grouped according to the geological age of the clay or shale formations which they contain.

The field data were collected mainly by Mr. Keele.

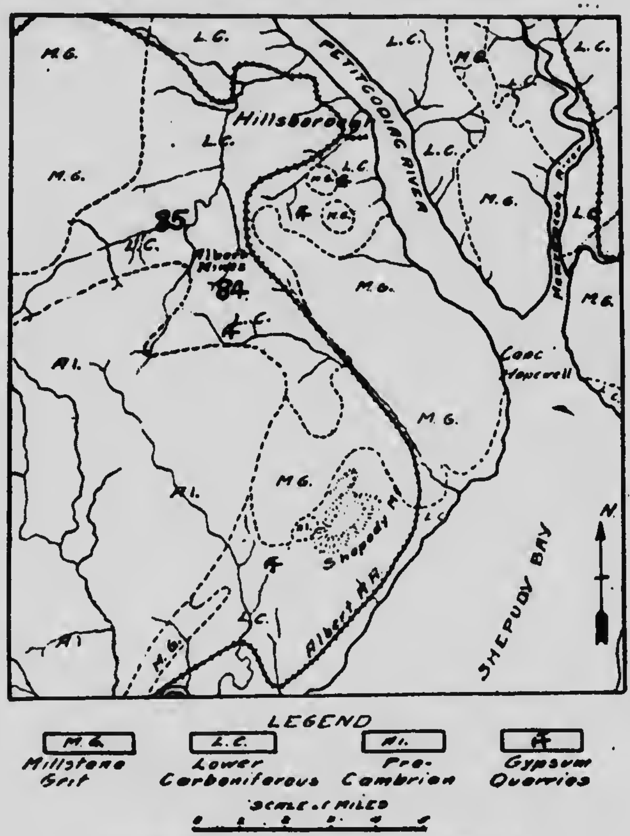

FIG. 16.—Map of Albert mines and vicinity, N.B.

Weldon Creek, near Albert Mines.—This shale is of very sandy character, and not highly plastic. It worked up with 19·8 per cent of water, and had an air shrinkage of 5·6 per cent. The average tensile strength was 74 pounds per square inch.

At cone 010 the fire shrinkage was 1 per cent, absorption 13·14 per cent, colour red.

At cone 05 the fire shrinkage was 1·3 per cent, absorption 11·22 per cent, colour dark red.

At cone 03 the fire shrinkage remained the same, with little difference in the absorption and colour.

The shale makes a good common brick.

Shale from Frederick Brook.—This material is a somewhat hard shale when fresh, but weathers down to a fairly soft mass. The sample worked up with 21·2 per cent of water to a somewhat gritty, though plastic mass, of which the air shrinkage was 6·2 per cent, and average tensile strength 137 pounds per square inch.

In burning it behaved as follows:—

WET-MOULDED BRICKLETS.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·3	13·00	Red.
05	0·6	14·55	"
03	1	13·37	"
1	5·3	7·32	" brown.
3	Fused.		

The shale burned to a good colour, had a fair ring at 010, and became steel hard at cone 03. It would make either common or pressed brick, but must be fired slowly, on account of the carbon it contains.

Chipman, Queens County.—About one mile east of Chipman a weathered shale is found in the cut of the Grand Trunk Pacific railway. The deposit, as exposed, shows a thickness of not less than 5 feet, and in the cut is capped by 8 to 14 feet of sandstone, but the same shale, covered by a thin soil layer, is found near the station.

The material was not tested in any great detail, as it appeared adapted for little else than common brick manufacture.

It was fairly plastic, but somewhat gritty, and had an air shrinkage of 5·2 per cent. At cone 010 it burned to a dark buff body, with under 1 per cent fire shrinkage, and 12·52 per cent absorption.

At cone 03 its colour was red, fire shrinkage 5·7 per cent, and absorption 4·14 per cent. It could be used for common brick making, and possibly dry-press brick.

Red shales, of plastic character, are found about 1½ miles west of Chipman, in the railway cut. They are very similar to red shales of the same age found near Albert Mines, Albert county, N.B.

Dorchester.—The only favourable shale exposures in this region were at a point about four miles from the town. This about 1½ miles out the road to the right of the court house, and in a shallow valley to the right of the road, near some sandstone quarries. The shales are similar to those found at Pugwash, but less weathered. They are also of lower Carboniferous age. The outcrops are small, but there may be an abundance of the material. Two samples represent, in part, their characters. One is from the west side of the brook, and the other is from the east side. The two samples were submitted to a few tests, and show a curious similarity. Both samples are quite gritty, but still work up to a fairly plastic mass. Tests of these are given in the table, Appendix I.

Coal Measures.

Grand Lake district.—The most important Carboniferous clays and shales are those found in the Grand Lake coal mining district, twenty-five miles east of Fredericton. The coal mines are located on the northern side of Grand lake, the localities at which coal is mined for shipping being on the Castle river and Salmon bay. The Grand Trunk Pacific railway traverses the area, the principal station in this district being at Chipman, on the Salmon river.

The coal seams where mined are found at depths varying from a few feet to 60 feet below the surface, the shallower seams being mined by open pits, and the deeper lying ones by drifts or shafts.

The main coal seam, which is about 30 inches thick, is overlain by 8 to 10 feet of hard grey shale, and underlain by 4 or 5 feet of rather soft clayey shale. The beds are nearly horizontal. Much of the top shale is removed in mining, while the shale floor is generally left.

The descriptions of the samples collected from the Coal Measures in the Grand Lake district follow.

Salmon Bay, N.B.—This material is a shale underlying the coal in the mines of the Canadian Coal Corporation, at Salmon bay. It is quite gritty, not very plastic, and required only 15 per cent water to work it up. The air shrinkage was 4·8 per cent, and the average tensile strength less than 25 pounds per square inch.

In burning it behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·0	10·20	Buff.
05	2·6	4·60	Red.
03	2·3	2·63	"
1	2·3	0·75	Brown.

The clay has a good ring even at cone 010, and burns steel hard at cone 05. It is probably only of value for brick manufacture, but unless used to make dry-press face brick would hardly be worth extracting.

The shale over the coal at the Canadian Coal Corporation's mine is also very gritty, but much more plastic than the under clay. It worked up with 16 per cent of water to a mass whose air shrinkage was 4·7 per cent; the average tensile strength was 62·5 pounds per square inch.

In burning it behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	12·60	Dark buff.
05	2	9·19	Light red.
03	2·3	7·78	Red.
1	3·3	3·9	Brown.
3	3·6	2·4	Red brown.

The shale does not burn to a very bright red colour in the gas kiln, but makes a steel hard body at cone 03. It also made a good dry-press bricklet at the same cone.

Flower Cove, N.B.—One sample represents the weathered outcrop of an under clay collected by Mr. F. W. Sypher.

It is soft, and works up with 26·4 per cent of water to a very smooth, plastic mass, whose air shrinkage was 8·6 per cent. The average tensile strength was 201 pounds per square inch. About 50 per cent of the clay passed through a 200 mesh sieve.

The fire tests yielded the following results:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·3	15·91	Cream.
05	1·3	14·60	Pink.
03	1·6	12·60	Cream pink.
1	5	8·87	"
5	7·7	0·26	Grey.

The clay burned steel hard at cone 1, and gave a nice cream colour, even when moulded dry-press.

The unweathered part of the deposit was somewhat hard, but, when crushed, worked up with 21 per cent of water to a very plastic but somewhat gritty mass whose air shrinkage was 8·2 per cent. The average tensile strength was 252 pounds per square inch.

The following results were obtained in burning the samples:—

Cone.	Fire Shrinkage.	Absorption.	Colou
	%	%	
010	0·3	12·37	Whitish.
05	1·6	11·97	Cream.
03	2	11·06	"
1	2·6	8·09	"
5	4·33	5·00	Speckled buff.

A dry-press brick burned at 03 was buff coloured, with 14·41 per cent absorption. The shale bricklets were nearly steel hard at cone 05, and thoroughly so at 03. A brick with a good ring was, however, obtained at cone 010. The clay burns to a fine-looking body, and should be of use for making buff face brick. It could also be employed in a terra-cotta body, and probably for making boiler setting brick.

The Barnes coal mine is situated near Minto, the present terminus of the New Brunswick Central railway. Great quantities of shale suitable for brick making are taken out with the coal. These shales, especially that which overlies the coal, are hard when first taken from the mine, but on being exposed to the weather on the waste dumps they slack down into a plastic mass.

Small samples of these shales were taken and submitted to a few physical tests, the results being as follows:—

The shale overlying the coal seam, when ground and passed through a 20 mesh sieve, formed a gritty but somewhat plastic mass, with an air shrinkage of 4·6 per cent.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·0	11·00	Light red.
03	4·0	5·29	Red.
1	4·7	1·30	Dark red.
3	4·6	2·30	Chocolate.
5	Viscous.		

The shale underlying the coal mixed with 24·2 per cent of water was quite plastic, but somewhat gritty. The air shrinkage was 6·6 per cent.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·15	13·27	Pink.
03	4·00	7·38	Red.
1	5·00	0·75	Dark red.
3	6·00	0·50	Red brown.
5	Viscous.		

Gives good common brick at the lower cones, or good dry-press at cone 1.

Minto, N.B.—The shale overlying the coal at the Evans mine works up to a mass of rather low plasticity, whose air shrinkage is 3·5 per cent. In burning, the wet-moulded bricklets behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
		%	
010	[illegible]	11 5	Pale red.
05	[illegible]	8 7	Red.
1	[illegible]	[illegible]	Red brown.
3	[illegible]	[illegible]	Red brown.

The body is steel hard at 05.

The under shale from the same mine gave better results, burning to a handsome buff with fused specks of iron oxide, and should be well adapted for the manufacture of pressed brick. The details of the tests are as follows: plasticity fair; average air shrinkage 3·8 per cent.

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0·3	15	Buff.
05	0·6	13·6	"
1	1	10·7	"
3	1·6	10·0	"
5	2·0	8·0	"
7	2·33	10·00	"
9	2·33	9·40	"
12	2·66	7·14	"

The fused iron specks began to show at cone 1.

Harcourt, N.B.—About two miles southwest of Harcourt a red shale of Carboniferous age outcrops along the Salmon river, and an attempt was made to utilize it for brick manufacture.

This is one of the smoothest shales which we saw in the Maritime Provinces. It has about 14 feet overburden, and Mr. Van Buskirk, the owner, attempted to work it by underground methods. A small kiln of bricks was built, but they were not burned sufficiently hard.

PLATE XXIX.

View of coal mine at Beersville, southeast of Harcourt, New Brunswick.

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Beersville, N.B.—Beersville lies about ten miles southeast of Harcourt, a station on the Intercolonial railway, and is connected with the main road by a switch. It lies in the Coal Measures area, and the beds outcrop on the slopes of a crescentic hill, formed by a bend in the river.

The coal bed, which is about 16 inches thick, is roofed by a very smooth shale, with some plant remains, and not over 4 to 5 feet thick, as sandstone outcrops that distance above the coal seam. Underlying the coal is a soft, dark bluish-grey shale, which is called fireclay. These two are found in all the drifts which are run in on the seam.

The coal is worked by the Imperial Coal Company.

The over clay, which is the harder of the two, is not highly plastic, and works up with 16·5 per cent of water to a mass whose air shrinkage was 4·5 per cent, and average tensile strength when dried 87 pounds per square inch.

At cone 010 its fire shrinkage and absorption were respectively 0 per cent and 10·23 per cent.

At cone 03 they were respectively 6 per cent and 1·6 per cent.

The shale burned to a hard body with a fair ring at cone 010, but was barely hard enough; it became steel hard at cone 05, and at cone 1 was a little beyond vitrification. When moulded dry-press it gave a hard body at cone 03. The clay needs to be slowly burned on account of its carbonaceous character, but could be used for pressed brick. It would, however, have to be worked in conjunction with the coal.

The under clay, when freshly taken from the mine, is not highly plastic, but weathering would no doubt improve its quality in this respect. In the laboratory it worked up with 20·2 per cent of water to a mass whose air shrinkage was 7 per cent, and average tensile strength 103 pounds per square inch. It gave a fair brick at cone 010, with a fire shrinkage of —2·3 per cent, and absorption of 13·64 per cent, but not very good colour.

At cone 05, the fire shrinkage was 2 per cent, absorption 8·67 per cent, bricklet steel hard, and colour red. It was vitrified at cone 1, and a good dry-pressed brick obtained at cone 03. The shale has to be fired slowly on account of its carbon contents. The material is not a fireclay.

Permian.

Red shales interbedded with sandstones of Permian age underlie the region in the vicinity of Sackville. These rocks have a dip of about 20 degrees from the horizontal. The shales weather easily into plastic clay, and their outcrops are marked by depressions between sandstone ridges. The shales could be mined along the outcrops for brickmaking. A small sample of the shale was collected, which showed the following physical properties:—

Quite smooth and plastic when mixed with 22 per cent of water. Air shrinkage 6 per cent, which is probably higher than it would be in actual practice. At cone 010 there was practically no fire shrinkage, and an absorption of 14·7 per cent. The colour of the brick was salmon pink. At cone 03 the brick was steel hard, and of a dark red colour. The fire shrinkage was 7 per cent, and the absorption 1·98 per cent.

Pleistocene.

Pleistocene clays, evidently of estuarine character, and bearing a strong structural and physical resemblance to the Nova Scotia clays, are found in the Annapolis and Shubenacadie valleys.

These clays are worked at several localities, including St. John and Fredericton, and make an excellent grade of common brick. Some portions of the deposits are sufficiently smooth and plastic to make drain tile, and common red eathenware.

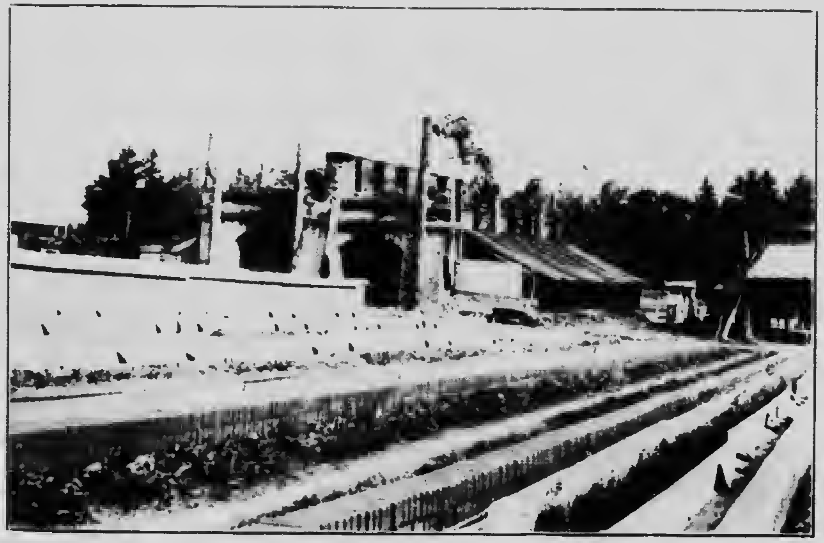
Fredericton, N.B.—There is a good exposure here of estuarine clay, about 1 mile north of Fredericton. The clay is clearly laminated, (Plate XXXII), yellowish above and bluish below. The total thickness ranges from 18 to 27 feet, and the clay is bottomed by a stony sand. It is evident that both the top and bottom of the clay are uneven. Thus, to the south the clay thins out up the slope, while if followed towards the St. John river, it dips under the floodplain sand deposit, whose thickness, where it is known to overlie clay, is from 6 to 14 feet.

The blue bottom clay outcrops in the river bank at low water. The deposit is evidently extensive, for blue clay is said to underlie the whole of the city of Fredericton. The clay is classed as a good grade of common brick clay, and has the following characters which are characteristic of the New Brunswick estuarine clays:—

PLATE XXX.

General view of brick works at Louisville, near Moncton, New Brunswick

PLATE XXXI.



Kilns at Ryan's brickyard, Fredericton, New Brunswick

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Plate XXXII.

Clay bank at Ryan's brickyard, Fredericton, New Brunswick.

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The material is very plastic and works up with 33·4 per cent of water to a mass whose air shrinkage is 7·8 per cent, and average tensile strength 109 pounds per square inch. In practice the air shrinkage is somewhat less. The material is quite free from sand, as 94 per cent of it passes a 200 mesh sieve. In burning it behaved as follows:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	22·08	Red.
05	3·6	1·69	Dark red.
03	10·3	0	Chocolate.
1	Fused.		

A dry-press bricklet at 03 had 0·91 per cent absorption.

The clay burns to a fair colour and a fair degree of hardness at 010, and is very hard and of deep red colour at cone 05, but at this temperature its shrinkage is too high. It would, however, probably make a good dry-press brick at this last cone.

St. John, N.B.—Several brick yards are in operation around this city, the product being largely consumed locally.

The clays at all the yards are somewhat similar, being evidently remnants of estuarine deposits laid down over this region, at no great elevation above sea-level.

At Lee's yard the material is a tough reddish-brown clay of variable depth; and while the pit does not exceed 5 feet in depth, they have gone down 30 feet in the clay, and found that the lower beds are blue. The lower surface of the deposit must be very uneven, as the underlying glacial drift comes close to the surface in several places. The clay is very tough, with some sandy streaks, but not as strongly laminated as that at Fredericton, N.B.

Moncton.—The brickworks are located at Louisville, (Plate XXX), two miles from Moncton. The material used is a glacial clay, situated almost at tide level, and underlain by till. The maximum depth of the clay is 7 feet. Some clay has also been dug from an embankment adjoining the yard.

CHAPTER IV.

The Clay-Working Industry.

NOVA SCOTIA.

Up to the present time the clay deposits of Nova Scotia have been little developed. Common brick are made at Annapolis, Middleton, and Avonport, in the Annapolis Valley region, and at Shubenacadie, and Elmsdale, in the Shubenacadie valley. Other brick plants have been established, and are in operation at Pugwash, New Glasgow, Sylvester, Eden Siding, and Mira river.

In most cases these are operated to supply a somewhat local demand, although the Pugwash and Annapolis bricks are often shipped some distance.

Common earthenware is made from the smoother phases of the estuarine clays, south of Elmsdale, in the Shubenacadie valley. Sewer pipe, flue linings, and drain tile are made from the shales at New Glasgow, and some drain tile are produced at Middleton, Avonport, Annapolis, and Shubenacadie. Most of the common brickyards turn out a few hand re-pressed brick. A hard brick, known in the trade as firebrick, is produced from the Carboniferous shales at Westville, in the Pictou field.

There is room for development in the Nova Scotia industry, but the product resulting from it will have to be marketed mainly outside the Province. For this reason, new plants should be favourably located for the shipment of their product.

There are few pressed brick works between Ontario and Nova Scotia, and this territory should afford a good field.

The estuarine clays of the Shubenacadie and Annapolis valleys could be used for making red pressed brick, while the fireclay at Shubenacadie is available for buff pressed brick.

Much of the smoother clay found in the Annapolis Valley could be employed for stoneware manufacture, and the same is true of the clay overlying the 13 foot seam at Inverness.

Much of the smoother clay found in the Annapolis valley could be used for making cheap art pottery, and terra cotta tiles. The making of this class of ware would involve the investment of little capital, and the output should find a ready market at the numerous much frequented summer resorts of this beautiful Province.

Large numbers of firebrick are consumed annually by the steel works at Sydney, but these are obtained mainly from Scotland, and the United States. The brick made at Westville have, however, given satisfaction when used as a lining for the ladles, into which the molten steel is poured from the reverberatory furnaces.

It is hoped that some attempt will be made to develop the fireclay at Shubenacadic for firebrick manufacture, and that later, when a railway is built up the Musquodoboit valley, the fireclay on Murphy brook, near Middle Musquodoboit, will also be mined for this purpose. The following details may serve to give a better idea of the clay-working industry in Nova Scotia.

Annapolis Royal.—The Buckler Brick Company, located at this town, is engaged in the manufacture of common brick and drain tile.

For making brick, clay enough for moulding 20,000 brick is mixed with four loads of sand, and the whole dumped into the pugmill of the stiff mud machine. The bricks are side cut and show but little lamination. Drying is done on pallet racks, and burning in Dutch kilns. The product is of a good red colour.

Mr. Buckler's father started a small yard on Sawmill creek about 1850, but this is no longer in operation. The present yard was established about 1885, using a double-header plunger machine, made by Norsworthy, of St. Thomas, Ontario. The product now made consists mainly of common brick, which are shipped to different ports on the Nova Scotia coast.

Tests of the brick are given in the following chapter.

Middleton.—A brick-yard, operated by the Middleton Brick Company, is located along the tracks of the Dominion and Atlantic railway on the western edge of the town. The clay is too plastic to be used alone for brick, and sand found underlying the clay is added to reduce the shrinkage.

The clay is tempered in a pugmill and moulded in a stiff mud machine. The bricks are dried on pallets, and burned in scove kilns. In burning, the clay shrinks 10 to 12 inches, in about 32 courses.

This is 2 inches more than the kilns settle at Avonport, and 6 to 8 inches more than at Bridgeton.

Some drain tile are also manufactured.

The clay burns to a good red colour, and gives a hard, saleable product. Tests of the brick are given in the following chapter.

Avonport.—There are two brick firms in operation at this point, viz., Robert Shaw, and Jacob Walton. Both yards use the estuarine clay. At the Shaw yard both common brick and drain tile are manufactured, the upper part of the bank being used for the former, and the lower part for the latter, but even the brick clay requires the addition of sand. The common brick are moulded on a steampower soft mud machine, or, if they are to be re-pressed, in a horse-power machine. The yard is also equipped with a stiff mud machine, and formerly some end-cut brick were made on it, but it is now used only for drain tile. Drying is done on pallet racks, and the brick are burned in scove kilns, set 37 courses high, settling 9 to 10 inches in burning. The tile are fired in a circular downdraft kiln.

The clay burns to a good red colour, but even if a little hard-burned tends to develop a greyish brown tinge.

At Walton's yard, which adjoins Shaw's, the method of manufacture is similar, as is also the clay.

These two yards are not the first started in this vicinity, for Elijah Eldekin established one at Wolfville between 1840 and 1850. Later an Englishman made a few bricks at Falmouth. Mr. R. Shaw commenced operations in 1862 at Hantsport, and worked 11 years, until his clay gave out. He then moved to Avonport, where his present yard is located.

A man named Albert Read had, however, before this begun to make bricks in 1867 on the site of Walton's present yard, but failed, and Walton is really his successor.

Shubenacadie.—James Miller and Sons: the works of this Company are located on the Intercolonial railway, about two miles north of Shubenacadie.

The clay deposit, which adjoins the yard, is worked by means of a cutter and scraper, and owing to the toughness and shrinkage of the clay about 10 per cent of sand is added, before it is moulded.

The machinery used consists of rolls, pugmill, and side-cut auger machine. The bricks are dried mostly in an open yard, although pallet racks are sometimes used.

Burning is done in scove kilns, set 32 courses high, and giving 10 inches settle. The clay seems capable of burning to a good red colour, but the harder bricks show a distinct greyish tint. A few are re-pressed in a handpower machine to supply occasional demand.

The sand used in moulding is not screened, and the bricks, therefore, contain numerous pebbles, which cause breakage of the wires, and also cracks in the brick in drying and burning.

The re-pressing is done only on the soft mud brick.

Samples for testing were taken of the well burned bricks, and also of some that were only moderately burned. The results of these tests will be found in the next chapter.

Elmsdale.—The Elmsdale Brick and Tile Company, Limited, is located on the Intercolonial railway, about 1½ miles north of the town.

The clay deposit is a shallow excavation adjoining the yard, and the clay is removed with plows and scrapers. It requires to be mixed with sand before moulding.

The bricks are moulded on a side cut, stiff mud machine, and burned in Dutch kilns.

Steam heated tunnels are employed for drying.

Some drain tile, fireproofing, and conduits are also made, the latter being salt-glazed.

Burning of the hollow ware is done in a circular downdraft kiln.

This yard was started by Lantz and Thompson, about 1900, the product being dry-pressed brick.

A second yard, belonging to the same Company, (Miller and Sons), is located about an eighth of a mile farther up the track. The clay is similar but the methods more primitive, and only common brick are turned out. There is a line of soak pits, in front of which a track is laid. The horse-power soft mud machines are placed on this, and moved along from one soak pit to another. Drying is done in open yards.

Spares Bros.—This yard is located about one mile up the track from the preceding. The clay and method of manufacture are similar.

Pugwash.—The only plant located at this locality is that of the Maritime Clay Works. The raw material used is a mellowed shale derived from the Carboniferous Limestone formation, the aim being to avoid the use of the fresh shale alone. The material is brought from the pit to the works on a narrow gauge steam road.

At the works it is put first through two pairs of rolls, and then charged into a pugmill for tempering. The moulding is done on a sidecut stiff mud machine, and re-pressed if front brick are demanded. Drying is done in tunnels, and burning in a Haigh continuous kiln.

The maufacture of bricks was started by this firm in 1898. They first tried surface clay from River Philip, near Oxford, there being at that time works near that point, but the clay was found to be unsatisfactory, and did not give good results on a dry-press machine, which was the type then employed. The plant was then moved to Pugwash, and the clay brought there and tried on a stiff mud machine. The shale was adopted later.

Other brick-yards have been in operation in this region in the past, but none are running now. About 50 years ago (1860) a man named Lowden began making hand-moulded brick from surface clay, at a yard situated just south of the present shale pit. This yard was run by different men for about 20 years. At Wallace Bridge, the Battye Brick Company commenced about 1903, and ran for 3 years. The plant is now idle.

New Glasgow.—Several brick plants are operated in the vicinity of this town, as described below.

The New Glasgow Brick and Tile Company is situated about 1½ miles southeast of New Glasgow station, and use a partly weathered Coal Measures shale. As they plow and scrape over a considerable area, it has not been worked to any great depth. There are a few scattered cobbles and pebbles in it, which may be drift material, although they are all of local rock.

The method of operation is somewhat more detailed than would seem necessary. The clay is first pulverized in a dry pan, whence it passes to a pugmill, and from this through rolls. Moulding is done on a small auger machine, and drying in open yards.

The bricks are burned in Dutch kilns with 12 to 13 inches settle. If burned too fast, they naturally develop black cores and swelling, due to the carbonaceous matter and sulphur in the clay. If properly fired, the clay burns to a hard brick of good red colour. Tests of the brick will be found in the next chapter.

The following determinations were made on the green brick, and one of the burned brick with black core:—

I, green brick; II, outer red portion of burned brick; III, black core of burned brick.

—	I	II	III
FeO	0·09	0·03	8·20
Fe_2O_3	8·34	9·96	0·97
C	0·12	....	Undet. Very small.
SO_3	None.	....	None.

The analyses were made by Mr. F. G. Wait, of the chemical laboratory, Mines Branch, Department of Mines, Ottawa.

The black core is due to the high percentage of ferrous iron, caused by improper burning, as a result of which the ferric iron was mostly reduced to the ferrous form. Had the moisture and carbon been driven off first, and the brick held at a low red to permit the iron to oxidize, this would not have occurred. As it was, there was an insufficiency of air present, the carbon robbed the ferric oxide of its oxygen, reducing it to the ferrous form. After the carbon was driven off, the heat was raised too rapidly and the pores of the clay closed up so that the iron in the interior of the brick did not get a chance to oxidize again.

George Brooks operates a small common brick-yard, located on the bank of McClellan brook, about 1⅗ miles east of south of New Glasgow station. The material used at the time of our visit was a somewhat silty clay taken from the bed of McClellan brook, but formerly glacial clay was used. The product is moulded on a soft mud brick machine, and occasionally re-treated on a hand-power re-press. It is dried in open yard and burned in a Dutch kiln.

Dominion Fire Brick and Tile Company.—These works were established in 1901, and lie immediately southeast of the Standard Drain Pipe Works. The material used is a bluish-black shale, which outcrops at the foot of the bluff along McClellan brook.

The exact thickness of this good shale is not known, but it is not more than 3 feet, so far as exposed, and it is covered by about 20 feet of shale, similar to that worked by Trotter, and this in turn by sandy and coaly shale and drift.

To work this deposit, therefore, it would have to be operated along the face of the bluff, and if worked into the bluff, the overburden would be heavy.

There is no doubt that the bottom shale stands more heat than the overlying shale, and also that worked for the pipe plant. The bottom bed in Brooks' bank also contains fewer concretions.

In considering this, however, it must be remembered that the beds outcropping along the brook level are not all part of the same bed. If the lines of strike given on Poole's map (Can. Geol. Surv. Part M, XIV, No. 833), are correct, and they appear to be, then the lower part of Brooks' shale bank is higher stratigraphically than the shale exposed in the new bank of the Standard Company, and lower than that in the old bank of the same Company.

The plant of the Dominion Fire Brick and Tile Company, which is not a very large one, is situated at the top of the bank, the shale being hoisted up an incline. It is first pulverized in a dry pan, and then, after tempering, moulded in a soft mud machine. Re-pressing is done in a handpower re-press. Mr. Brooks has one circular downdraft kiln. The re-pressed bricks have a granular structure like those made in a dry-press. It is said that the bricks made from the lower clay had been sold for lining ladles. It is also used for making bag-wall bricks for use in the kilns at the pipe works.

Standard Pipe Works.—This plant is a branch of that firm, and of the same name, located at St. Johns, Que. The product consists chiefly of sewer-pipe, but flue linings, hollow blocks, fireproofing, and drain tile are also manufactured.

The firm has a large and well equipped factory.

The material originally used was a red boulder clay, but in recent years a mixture of the shale and boulder clay, and also the shale alone, have been tried. The mixture stands less fire than the shale, but is said to take a better salt-glaze.

In making pipe, they have tried to use shale alone, but this, on account of its carbonaceous character, has to be very slowly fired in order to prevent bloating.

The clay also shows a rather high percentage of soluble salts, and this was at first believed to prevent the formation of a good salt-glaze. This difficulty was subsequently found to be due to the ware not being fired hard enough. The salt-glaze is improved, however, by adding some surface clay to the shale. The siderite concretions may cause fused specks in the ware.

The shrinkage of the sewer pipe mixture is a little over 1 inch per foot, and no pipes of more than 24 inches diameter are made.

The market for the ware is chiefly outside the Province.

Eden Siding.—Miller Brothers have one yard in operation at this locality, the product of the same being common brick, which are made from a mixture of the surface clay, with about 10 per cent sand.

The materials are mixed in a soak pit, and moulded in a horse-power soft mud machine. Drying is done in an open yard, the brick being sprinkled with sand, as it is claimed that this prevents cracking. The air dried brick are burned in scove kilns set 32 courses high.

The product of the yard goes mainly to Sydney, but some brick are also shipped westward along the line of the Intercolonial railway.

Mira River, B.C.—The works of the Mira Brick Company are located on Mira river about four miles from its mouth. The product is made of a mixture of about two-thirds blue clay and one-third sand, but the latter is not screened. A belt conveyer takes the clay from the bank to the works, where it is discharged into the pugmill of the soft mud brick machine. Drying is done on pallet racks, and burning in a seven chamber Haigh continuous kiln. The product goes mainly to Glace Bay and Sydney.

NEW BRUNSWICK.

Fredericton.—M. Ryan and Son are the only brick manufacturers at this city.

The material used is an estuarine clay somewhat similar to that worked in the Annapolis valley of Nova Scotia.

The clay is moulded in a soft mud machine, without any preliminary pugging, but nevertheless makes a good grade of brick.

The freshly moulded bricks are hacked at once, and air dried in that manner, although at the time of our visit Mr. Ryan contemplated the erection of pallet racks.

Burning is done in a patent double-chambered downdraft kiln, each half having a capacity of 90,000 brick.

The clay settles 12 inches in 31 courses, during the burning. Tests of the brick are given in the next chapter.

St. John.—There are several yards in operation in the immediate vicinity of the city, all engaged chiefly in the manufacture of common brick.

At Lee's yard the clay, when dug, is thrown into soak pits, and then taken to the machine, where one-third sand is added. Moulding is done on a stiff mud, sidecut machine, and drying on pallet racks.

The bricks are burned in scove kilns, showing 8 inches settle in 38 courses. Some of the bricks are re-pressed by hand power, and sold for facing. Tests of the product are given in a later chapter.

The yard of John Lee and Company is located about 1½ miles west of the city, on the Little River road. They have a second yard about a quarter of a mile nearer town. The clay and methods employed are similar to those used at the first Lee yard, described before.

B. Mooney and Sons also operate a common brick-yard, located at Fairville, a suburb of St. John. The brick are moulded by the soft mud process, dried on pallet racks, and burned in scove kilns.

J. W. Foley and Company have the only pottery in operation at St. John, the works being located on the Silver Falls road. The raw material is imported mainly from New Jersey, U.S.A., and the product consists chiefly of butter crocks, teapots, flower pots, and jars.

CHAPTER V.

Tests of Brick.

At all of the yards visited samples of brick were collected. In every case, unless otherwise stated under the tests, an effort was made to collect normally burned samples.

These samples were then sent to Professor A. Macphail, of the Kingston School of Mines, and subjected to crushing, transverse, and absorption tests. The results of these tests, together with a description of the method of testing, are given below.

METHOD OF TESTING.

The transverse tests were undertaken in general on six bricks. They were tested on the flat, being supported on two circular knife-edge supports at the ends, and loaded in the centre, the load being applied by a steel circular knife-edge. The supports were 7 inches apart in every case, and were self-adjusting, and hung so as to give a full bearing over the full width of brick. In every case the appearance of the fracture is noted. In the table of transverse tests, the dimensions of the bricks are given under 'Size,' the breaking load at the centre under 'Load,' and the modulus of transverse rupture under 'Mod.' calculated by the following formula:—

$$\text{Modulus} = \frac{3 \text{ Wl}}{2 \text{ bd}^2}$$

Where W is the breaking load in pounds; l the length in inches; b the width of brick; and d the depth in inches.

CRUSHING TESTS.

For these tests half of each brick broken in the preceding test was prepared by sawing the fractured end by means of a diamond saw to a plane surface. As the capacity of the testing machine used was only 100,000 pounds, and in some cases the crushing strength of the half bricks would be more than this amount, the specimens had to be re-sawed so as to come within the capacity of the machine. The results are given in pounds total load, and also in per square inch of the specimen. They were crushed on the flat. As the bricks were somewhat irregular in shape, it was necessary to provide some form of cushion between the crushing blocks and the brick itself and a sand cushion was used. A bed of fine dry sand (passing through 40 mesh sieve) one-eighth of an inch thick, was placed upon the lower crushing block of the machine. The brick was placed upon this cushion of sand and another bed of sand was placed upon the top of the brick. The upper crushing block was then lowered so as to just touch the sand on top of the brick, and the sand was struck off by means of a thin steel straight edge so as to leave the surfaces strictly parallel, and then the crushing was proceeded with. The sand cushion in each case was one-eighth inch thick before compression. It is believed that greater uniformity is gained in this way than by any other method.

ABSORPTION TESTS.

For this test the half bricks were first thoroughly dried by being kept in a steam-heated room for four weeks. They were then weighed, a Fairbanks scale weighing to single grams being used. The bricks were then immersed in water, where they remained for 24 hours, and after being slightly dried on the outside with blotting paper, were weighed again. Absorption is expressed as a percentage of water absorbed referred to the weight of the brick when dry.

RESULTS OF TESTS.

The following tables give the results of these tests:—

STIFF MUD BRICK, SHAW'S BRICK-YARD, MIDDLETON.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	8 x 3⅞ x 2¼	1145	715	3⅞ x 3¾	60260	4150	890	1045	114	Small quartz pebbles.
2	7⅞ x 3⅝ x 2⅛	920	570	3⅝ x 3¾	54310	4000	945	1059	120	Lumps of clay.
3	8 x 3⅝ x 2⅛	1065	660	4 x 3⅝	87000	5960	729	803	101	
4	7¾ x 3¼ x 2⅛	1840	1150	3½ x 3¼	64950	5660	895	951	62	
5	8 x 3⅝ x 2¼	1335	845	3⅝ x 2½	22990	2460	1071	1240	158	One large pebble.
6	7¾ x 3⅝ x 2⅛	1360	850	3¾ x 3¾	47890	3410				

SOFT MUD BRICK, LEE BROS., ST. JOHN, N.B.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¾ x 3⅞ x 2$\frac{3}{16}$	1340	600	3¾ x 3⅞	72160	4950	697	762	9·3	Fine grain, clear break.
2	8⅛ x 3¾ x 2¾	1580	710	3¾ x 3½	55680	4100	1210	1363	12·6	Small lumps of clay.
3	8⅛ x 3¾ x 2½	2000	895	3¾ x 3½	52620	3880	1018	1125	10·5	Rough and uneven, contains lumps of clay.
4	8⅛ x 3⅞ x 2⅛	2120	960	3¾ x 3½	50620	3730	1304	1405	7·6	Well burnt, fine grain.
5	8⅛ x 3¾ x 2¾	3560	1590	3¾ x 3¾	94000	6680	1236	1336	9·7	Clear break.
6	8 x 3¾ x 2⅛	2050	920	3¾ x 3¾	38240	2732	1126	1255	11·4	Well burnt, lumps of clay.

STIFF MUD BRICK, MILLER'S BRICK-YARD, SHUBENACADIE.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¾ x 3⅝ x 2¼	1195	662	3⅝ x 2¼	21400	2620	1151	1283	11·5	Fine texture, over burnt; secondary line of fracture.
2	7¾ x 3¾ x 2⅜	1740	964	3¾ x 2¼	25000	2960	1249	1433	14·85	Lumps of clay.
3	7¾ x 3¾ x 2¼	1545	855	3¾ x 2¼	38200	4500	1212	1355	11·8	Small pebbles.
4	7⅝ x 3¾ x 2¼	1460	808	3¾ x 3	54000	4800	1085	1215	12·0	Sand and clay lumps.
5	7¾ x 3⅝ x 2¼	1530	847	3⅝ x 2½	35000	3875	1048	1212	15·75	Very hard, clay lumps; secondary line of fracture.
6	7¾ x 3¾ x 2¼	1615	895	3¾ x 2¼	40000	4740	1209	1350	11·74	A few pebbles and clay lumps.

STIFF MUD BRICK, BUCKLER BRICK CO., ANNAPOLIS.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	8 x 3¾ x 2¼	2100	1160	3¾ x 3¼	80900	6650	1163	1251	7·6	Quartz pebbles and few fire cracks.
2	8 x 3¾ x 2¼	1895	1020	3¾ x 3¼	98180	8370	1189	1259	5·9	" " "
3	8 x 3¾ x 2¼	2100	1160	3¾ x 3⅜	83400	6610	1100	1171	6·45	" " "
4	8 x 3¾ x 2¼	2140	1180	3¾ x 3¼	78400	5980	1074	1158	7·85	" " "
5	8 x 3¾ x 2¼	2070	1145	3¾ x 3¼	70850	6000	1175	1248	6·2	Pebbles, fire cracks and clay lumps.
6	8 x 3¾ x 2¼	1820	1015	3¾ x 2¼	53720	5210	1077	1154	7·2	" " "

STIFF MUD BRICK, MILLER'S BRICK-YARD, ELMSDALE.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¼ x 3¼ x 2¼	1875	1175	3¼ x 3⅜	88680	7550	942	996	5·9	Fire cracks and pebbly.
2	7⅜ x 3⅜ x 2	1460	910	3⅝ x 3⅜	65470	5350	903	946	4·75	Not very compact; lumps of clay.
3	7½ x 3½ x 2¼	1770	1100	3¾ x 3½	96550	7350	908	933	2·75	Well burnt; a few pebbles.
4	7¼ x 3½ x 2¼	2070	1280	3¼ x 3½	76050	6200	1023	1055	2·6	Over burnt; few fine pebbles
5	7¼ x 3½ x 2¼	1575	990	3⅝ x 3¼	100720	7950	938	973	3·73	Slightly overburnt.
6	7½ x 3½ x 2¼	1775	1100	3¾ x 3½	93940	7150	897	939	4.68	Slightly overburnt, few pebbles.

SOFT MUD BRICK, RYAN, FREDERICTON.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¾ x 3¾ x 2¼	1825	1050	3¾ x 3¼	82570	6300	986	1147	16·3	Well burnt.
2	7¾ x 3⅜ x 2¼	2730	1560	3⅜ x 2¾	71660	7550	1025	1162	13·4	Clay streaks.
3	7¼ x 3¼ x 2¼	2090	1190	3¼ x 2⅞	46800	4850	869	957	10.2	"
4	7¾ x 3⅜ x 2¼	3540	2100	3⅝ x 3¼	90140	6550	968	1066	8·0	Vitrified.
5	7¾ x 3⅜ x 2⅜	1460	835	3⅝ x 3⅝	43620	3580	429	532	24·0	Soft yellow.
6	7¼ x 3¾ x 2⅜	1900	1070	3¾ x 3⅜	17470	1380	961	1207	25·6	"
7	7¼ x 3⅜ x 2¼	1520	870	3⅜ x 3	98000	9700	965	1046	8·4	Over burnt.

STIFF MUD BRICK, NEW GLASGOW BRICK AND TILE CO., NEW GLASGOW.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¾ x 3¾ x 2¼	2800	1550	3¾ x 3½	28000	2130	1045	1165	11·75	Well burnt.
2	7¾ x 3¾ x 2⅜	1200	660	3¾ x 2¼	16500	1760	660	804	21·8	Under burnt.
3	7¾ x 3¾ x 2¼	1890	1020	3¾ x 3½	23000	1760	890	1032	15·9	Under burnt, yellow.
4	7⅝ x 3¾ x 2⅜	1600	785	3¾ x 2½	58000	6400	955	1037	4·2	Over burnt, black core.
5	7¾ x 3½ x 2¼	2000	1100	3½ x 3½	45000	3670	995	1052	5·75	Well burnt.
6	7½ x 3⅝ x 2¼	4800	2650	3⅝ x 2¾	60000	6000	1105	1192	7·87	"

SOFT MUD BRICK, MIRA BRICK CO., MIRA RIVER, C.B.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¾ x 3½ x 2¼	2200	1240	3½ x 2½	88000	10050	1057	1098	4·0	Lumps of clay and pebbles.
2	7¾ x 3¾ x 2¼	2650	1460	3¾ x 2¼	35000	3730	1495	1612	7·86	
3	7½ x 3¾ x 2¼	2100	1180	3¾ x 2¾	62000	6020	1357	1455	7·25	
4	7¾ x 3¾ x 2¼	2700	1520	3¾ x 3⅝	110000	8100	1127	1215	7·85	Over burnt, coarse texture, many pebbles.
5	7¾ x 3¾ x 2¼	2800	1580	3¾ x 2½	57000	6075	1147	1212	5·7	Coarse texture, many pebbles.
6	8 x 3¾ x 2¼	1700	810	3¾ x 2¼	31000	2900	1272	1385	8·9	

SOFT MUD BRICK, SHAW BRICK WORKS, AVONPORT, N.S.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¾ x 3⅝ x 2¼	1260	695	3⅝ x 2⅜	43000	4300	1135	1269	11·85	Fine, well burnt.
2	7½ x 3½ x 2¼	2160	1190	3½ x 2¼	53000	6740	1280	1375	7·4	Over burnt.
3	7¾ x 3¾ x 2¼	500	280	3¾ x 2⅜	31000	3005	1167	1334	14·4	Soft, under burnt.
4	7¾ x 3¾ x 2¼	560	290	3⅝ x 2⅝	30000	3650	985	1095	11·2	Under burnt.
5	8 x 3¾ x 2¼	660	360	3⅝ x 2¼	8000	950	1047	1192	13·9	
6	7¾ x 3¾ x 2¼	860	475	3¾ x 2⅝	18000	2130	972	1119	15·1	Medium burnt.

STIFF MUD BRICK, MARITIME CLAY WORKS, PUGWASH.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7½ x 3⅞ x 2¼	1330	760	3⅞ x 3	62000	5510	1003	1125	12·2	Small pebbles.
2	7⅝ x 3½ x 2¼	3040	1730	3½ x 3	91000	8660	1110	1154	4·0	
3	7⅞ x 3¾ x 2¼	1370	780	3⅞ x 2⅜	50000	5080	1180	1300	10·2	
4	7½ x 3⅝ x 2¼	2470	1410	3⅝ x 3¾	*120000	8830	1051	1117	7·25	
5	7½ x 3½ x 2¼	4000	2280	3½ x 3	64500	6130	1190	1228	3·2	
6	7¾ x 3⅝ x 2¼	2010	1140	3¾ x 2⅝	61000	6860	1069	1174	9·9	

* Estimated.

RE-PRESSED BRICK, MARITIME CLAY WORKS, PUGWASH.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	7¾ x 3½ x 2¼	2700	1450	3¾ x 2¼	78000	6240	1125	1268	7·8	Well burnt. Fine grain.
2	7¾ x 3¾ x 2¼	2850	2080	3½ x 3¾	54000	5400	1167	1344	6·6	
3	7¾ x 3½ x 2¼	2100	1120	3½ x 2¼	51000	5840	1264	1304	10·3	Pebbles and pieces of clay.
4	7¾ x 3½ x 2¼	1700	910	3½ x 2¼		1880	1140	1272	11·6	

FIRE BRICK, MADE STIFF MUD, RE-PRESSED, INTERCOLONIAL COAL CO, WESTVILLE.

Number.	Transverse Tests.			Crushing Tests.			Absorption.			Fracture.
	Size.	Load.	Mod.	Size.	Load.	Sq. in.	Dry.	Wet.	Per cent	
1	9 x 4½ x 2½	2000	855	4½ x 2¼	24000	2438	1720	1796	4·4	Many small pebbles.
2	9 x 4½ x 2½	1400	600	4½ x 2¼	25000	2250	1626	1774	9·15	
3	9 x 4½ x 2½	2400	1030	4½ x 2¼	29000	2275	1723	1807	4·9	
4	9 x 4½ x 2½	2500	1070	4½ x 2¼	30000	2400	1686	1792	5·7	
5	9 x 4½ x 2½	2500	1070	4½ x 2¼	15000	1545	1580	1644	4·05	
6	9 x 4½ x 2½	2100	900	4½ x 2¼	21000	1980	1596	1664	5·6	

PART II.

THE ORIGIN AND PROPERTIES OF CLAY.

As many persons having occasion to use this report may not have an extended knowledge of the origin, mode of occurrence, and properties of clay, it seems desirable to add some information on this subject.

Origin of Clay.

Definition.—Clay is the term applied to those earthy materials occurring in nature the most prominent property of which is that of plasticity when wet. On this account they can be moulded into almost any desired shape, which is retained when dry. Furthermore, if heated to redness, or higher, the material becomes hard and rock like. Physically, clay is made up of a number of small particles, mostly of mineral character, ranging from grains of coarse sand to those which are of microscopic size, or under 1/1000 of a millimetre in diameter. Mineralogically, it consists of many mineral fragments of varying degrees of freshness, and representing chemically many different compounds, such as oxides, carbonates, silicates, hydroxides, etc. Some of the constituents are of colloidal character.

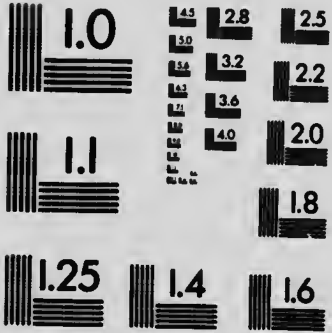
Weathering Processes Involved.—Clays are always of secondary origin, and result primarily from the decomposition of rocks, very frequently from rocks containing feldspar; but in some cases rocks containing little or no feldspar, such as gabbro or serpentine, may, on weathering, produce some of the most plastic clays known.

In order to trace the changes occurring in the formation of clay we may take the case of a rock like granite.

When such a mass of rock is exposed to the weather, minute cracks are formed in it, due to the rock expanding when heated by the sun and contracting when cooled at night, or they may be joint-planes formed by the contraction of the rock as it is cooled from a molten condition. Into these cracks the rain water percolates, and, when it freezes in cold weather, it expands, thereby exerting a pry-

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



ing action, which further opens the fissures, or may even wedge off fragments of the rock. Plant roots force their way into these cracks, and, as they expand, supplement the action of the frost, thus further aiding in the breaking up of the mass. This process alone, if kept up, may reduce the rock to a mass of small angular fragments, or even a mass of sand.

The rock having been opened up by disintegrative forces, the silicates are next attacked by the surface waters, although those exposed on the surface of the stone may already have begun to change.

The most prominent chemical change is the alteration of the feldspar grains to a white, powdery substance, known as kaolinite, a hydrous silicate of alumina. The alteration of the feldspar is termed kaolinization. Other silicates, such as hornblende, probably undergo similar changes.

As a result of these changes the entire rock may slowly but surely break down to a clayey mass.

Residual Clay.—Where the clay is thus found overlying the rock from which is was formed, it is termed a residual clay, because it represents the residue of rock decay, and its grains are more or less insoluble.

If a granite which is composed chiefly of feldspar decays under weathering action, the rock will be converted into a clayey mass, with quartz and mica scattered through it. Remembering that the weathering began at the surface and has been going on there for a longer period than in deeper portions of the rock, we should expect to find, on digging downward from the surface, (A) a layer of fully formed clay, (B) below this a poorly defined zone containing clay and some partially decomposed rock fragments, (C) a third zone, with some clay and many rock fragments, grading downward into the solid bed-rock. In other words, there is usually a gradual transition from the fully formed clay at the surface into the parent rock beneath. The only exception to this is found in clays derived from limestone, where the passage from clay to rock is sudden. The reason for this is that the change from limestone into clay does not take place in the same manner as granite. Limestone consists of carbonate of lime, or carbonate of lime and magnesia, with a variable quantity of clayey impurities, so that when the weathering agents attack the rock, the carbonates are dissolved by the surface waters, and the insoluble clay impurities are left behind as a mantle on the undissolved rock, the change from rock to clay being, therefore, a sudden one, and not due to a gradual breaking down of the minerals in the rock, as in the case of granite.

Kaolin.—A residual clay derived from a rock composed entirely of feldspar, or one containing little or no iron oxide, is usually white, and, therefore, termed a kaolin. Deposits of this type may contain a high percentage of the mineral kaolinite[1], this being assumed, because, after washing the sand out of such materials, the silica, alumina, and water in the remaining portion are in much the same ratios as in kaolinite, although, as previously mentioned, other aluminous silicates may at times be present.

A clay made up entirely of kaolinite is sometimes termed a pure clay, but since the term clay refers to a physical condition, and not a definite chemical composition, it would perhaps be more correct to term kaolin the simplest form of clay.

Form of Residual Deposits.—The form of a residual clay deposit, which is also variable, depends on the shape of the parent rock. Where the residual clay has been derived from a great mass of granite or other clay-yielding rock, the deposit may form a mantle covering a considerable area. On the other hand, some rocks, such as pegmatites (feldspar and quartz), occur in veins, that is, in masses having but small width as compared with their length, and in this case the outcrop of residual clay along the surface will form a narrow belt.

Clay derived from a rock containing much iron oxide will be yellow, red, or brown, depending on the iron compounds present. Between the white clays and the brilliantly coloured ones others are found representing all intermediate stages, so that residual clays vary widely in their colour.

The depth of a deposit of residual clay will depend on climatic conditions, character of the parent rock, topography, and location. Rock decay proceeds very slowly, and in the case of most rocks the

[1] The terms *kaolinite*, referring to the mineral, and *kaolin*, referring to the clay-mass, are often carelessly confused even by scientific writers, although there seems to be little excuse for so doing.

rate of decay is not to be measured in months or years, but rather in centuries. Only a few rocks, such as some shales or other soft rocks, change to clay in an easily measurable time. With other things equal, rock decay proceeds more rapidly in a moist climate, and consequently it is in such regions that the greatest thickness of residual materials is to be looked for. The thickness might also be affected by the character of the parent rock, whether composed of easily weathering minerals or not. Where the slope is gentle, or the surface flat, much of the residual clay will remain after being formed, but on steep slopes it will soon wash away.

In some cases the residual materials are washed but a short distance, and accumulate on a flat or very gentle slope at the foot of the steeper one, forming a deposit not greatly different from the original ones, although they are not, strictly speaking, residual clays[1].

Deposits of residual clay are exceedingly rare in all parts of the Dominion of Canada, for the reason that nearly all of those formed have been swept away by glacial action. None are known to occur in Nova Scotia, except the small pocket referred to on Coxheath mountain.

Transported Clays.

Sedimentary Clays.

Origin.—As mentioned above, residual clays rarely remain on steep slopes, but are washed away by rainstorms into streams, and carried off by these to lower and sometimes distant areas. By this means residual clays, possibly of different character, may be washed down into the same stream and become mixed together. This process of wash and transportation can be seen in any abandoned clay bank, where the clay of the slopes is washed down and spread out over the bottom of the pit.

As long as the stream maintains its velocity it will carry the clay in suspension, but if its velocity be checked, so that the water becomes quiet and free from currents, the particles begin to settle on the bottom, forming a clay layer of variable extent and thickness. This may be added to from time to time, and to such a deposit the name of sedimentary clay is applied. All sedimentary clays are stratified or made up of layers, this being due to the fact that one

[1] *Colluvial deposits* of G. P. Merrill.

layer of sediment is laid down on top of another. These layers may also vary in thickness, and since there is less cohesion between unlike particles, the two layers will tend to separate along their line of contact.

As the finer material can only be deposited in quiet water, and coarse material in disturbed waters, so from the character of the deposit we can read much regarding the conditions under which it was formed. If, therefore, in the same bank, alternating layers of sand, clay, and gravel are found, it indicates a change from disturbed to quiet water, and still later rapid currents over the spot in which these materials were deposited. The commonest evidence of current deposition is seen in the cross-bedded structure of some sand beds where the layers dip in many different directions, due to shifting currents which have deposited the sand in inclined layers.

Sedimentary clays can be distinguished from residual clays chiefly by their stratification, and also by the fact that they commonly bear no direct relation to the underlying rock on which they may rest.

Structural Irregularities in Sedimentary Clays.—All sedimentary clays resemble each other in being stratified, but, aside from this, they may show marked irregularities in structure.

Thus, any one bed, if followed from point to point, may show variations in thickness, pinching or narrowing in one place and thickening or swelling in others.

Occasionally a bed of clay may be extensively worn away or corroded by currents subsequent to its deposition, leaving its upper surface very uneven, and on this an entirely different kind of material may be deposited, covering the earlier bed, and filling the depressions in its surface.

CLASSIFICATION OF SEDIMENTARY CLAYS.

The general character of sedimentary clays is more or less influenced by the locality and conditions of deposition, which enables us, therefore, to divide them into the following classes:—

Marine Clays.—This class includes those sedimentary clays deposited on the ocean bottom, where the water is quiet. They have, therefore, been laid down at some distance from the shore, since nearer the land, where the water is shallower and disturbed, only coarser materials can be deposited. Beds of clay of this type may be of vast extent and great thickness, but will naturally show some variation, horizontally at least, because the different rivers flowing into the sea usually bring down different classes of material. Since most marine clays have become deeply buried under other sedimentary rocks subsequent to their deposition, they are often changed to shale: these shale beds, moreover, are sometimes interstratified with sandstones. The shale is now found exposed, because the ocean bottom has been uplifted, and the overlying rocks worn away.

Estuarine Clays.—These form a second type of some importance in certain areas. They represent bodies of clay laid down in shallow arms of the sea, and are consequently found in areas that are comparatively long and narrow, with the deposits showing a tendency towards basin shapes. If strong currents enter the estuary from its upper end, the settling of the clay mud may be prevented, except in areas of quiet water in recesses of the bay shore. Or, if the estuary is supplied by one stream at its head, and this of low velocity, the finer clays will be found at a point most distant from the mouth of the river. In such cases we should anticipate an increase in coarseness of the clay bed, or series of beds, as they are followed from what was formerly the old shore line up to the mouth of the former river that brought down the sediment.

Estuarine clays often show sandy laminations, and are not infrequently associated with shore marshes, due to the gradual filling up of the estuary, and the growth of plants on the mud flats thus formed. The clays of the Annapolis and Shubenacadie valleys are of estuarine type.

Swamp and Lake Clays.—Swamp and lake clays constitute a third class of deposits, which have been formed in basin-shaped depressions occupied by lakes or swamps. They represent a common type, of variable extent and thickness, but all agree in being more or less basin-shaped. They not infrequently show alternating beds of clay and sand, the latter in such thin laminae as to be readily overlooked, but causing the clay layers to split apart easily. Many of the lake clays are directly or indirectly of glacial origin, having been laid down in basins or hollows along the margin of the continental ice sheet, or else in valleys that have been dammed up by the accumulation of a mass of drift across them. This wall of drift serves to obstruct the drainage in the valley, thus giving rise to a lake, in which the clay has been deposited. Clay beds of this type are extremely abundant in all glaciated regions. They are usually surface deposits, of varying thickness, often highly plastic, and more or less impure. Their chief use is for common brick and earthenware, and they are rarely of refractory character.

Flood-plain and Terrace Clays.—Many rivers, especially in broad valleys, are bordered by a terrace or plain, there being sometimes two or more, extending like a series of shelves, or steps, up the valley side. The lowest of these is often covered by the river during periods of high water, and is consequently termed the flood-plain. In such times much clayey sediment is added to the surface of this flood-terrace, and thus a flood-plain clay deposit may be built up.

Owing to the fact that there is usually some current setting along over the plain when it is overflowed, the finest sediments cannot settle down, except in protected spots, and consequently most terrace clays are rather sandy, with here and there pockets of fine, plastic clay. They also frequently contain more or less organic matter. Along its inner edge the terrace may be covered by a mixture of clay, sand, and stones, washed down from neighbouring slopes.

Drift or Boulder Clays.—In that portion of the United States formerly covered by the continental ice sheet there are occasional deposits of clay formed directly by the glacier. These are usually tough, dense, gritty clays, often containing many stones. The material deposited by the ice (till) is usually too stony and sandy to serve for brick making, although often known as boulder clay. Locally, however, although the ice-transported material has been largely ground to a fine rock flour, the boulder clay is plastic enough, and not too full of stones for use. Such deposits are mostly of limited extent, impure, and of little value.

In addition to this type of clay, formed directly by the ice, there were clays deposited in lakes or along flood-plains by the streams issuing from the glacier. These were composed of material derived from the ice, but since they were deposited by water they were stratified, and may properly be classed as lacustrine, estuarine, or flood-plain clays of glacial age. Boulder clays, although abundantly distributed, are often too stony to be of much value for the manufacture of clay products.

Æolian Clays.—In many parts of the west there is found a silty, often calcareous clay, termed the loess. This, although commonly a water deposit, may at times have been formed by wind action. It can, therefore, properly be classed as transported clay, and also shows a stratified structure.

Classification of Clays.

Considering the different ways in which clays have been formed, it is possible to formulate the following classification, based primarily on their origin, and also bringing out, somewhat, their commercial characters.

A. *Residual clays.* (By decomposition of rocks in place).

- I. Kaolins or china clays. (White burning, and derived from igneous or metamorphic rocks low in iron oxide).
  - (*a*). Vein-like deposits derived from pegmatite veins or dikes of igneous rock, such as rhyolite.
  - (*b*). Blanket deposits, derived from extensive areas of igneous rock.
  - (c). Pockets in limestone, as the indianaite of Indiana, U.S.A.
- II. Red-burning residuals, derived from different kinds of rocks. These may be formed by the decomposition of such rocks as granite, by a process of solution as in limestone, or by simple disintegration as in many shales.

B. *Colluvial clays,* representing deposits formed by wash from the foregoing, and of either refractory or non-refractory character.

C. *Transported clays.*

- I. Deposited in water.
  - (*a*). Marine clays or shales. Deposits often of great extent.

    White burning clays. Ball clays and plastic kaolins.

Fireclays or shales. Buff burning.

Impure clays or shales. {Calcareous. / Non-calcareous.}

(*b*). Lacustrine clays (deposited in lakes or swamps).
Fireclays and some shales.
Impure clays or shales, red-burning.
Calcareous clays, usually of surface character.

(*c*). Flood-plain clays. Usually impure and sandy.

(*d*). Estuarine clays (deposited in estuaries). Mostly impure and finely laminated.

Secondary Changes in Clay Deposits.

Changes often take place in clays subsequent to their deposition. These may be local or widespread, and in many cases either greatly improve the deposit or render it worthless. The marked effect of some of these changes is often well seen in clay beds of which only a portion has been altered. These secondary changes are of two kinds, viz., mechanical and chemical.

MECHANICAL CHANGES.

Formation of Shale.—Clay deposits laid down on the ocean floor often become covered by many hundreds of feet of other sediments, whose weight alone is often sufficient to cause a consolidation and hardening of the clay mass. Deposition of mineral matter around the grains may cement them together and aid in the hardening process. Such a consolidated clay is termed a shale. When ground and [illegible]h water, it may develop high plasticity. Shale deposits [illegible] received their properties by deep burial, but are now often [illegible] the surface because the overlying strata have been worn [illegible]

Shale beds were originally formed in a more or less horizontal position, but since then have often become more or less tilted by uneven movements of the earth's crust. As evidence of this the shale beds near Grand Lake, N.B., are nearly flat, while those around Sydney or Joggins show varying angles of dip.

CHEMICAL CHANGES.

Nearly all clay deposits are frequently changed superficially, at least, by the weather, or by surface waters. The changes are chiefly chemical, and can be grouped under the following heads: 1, change of colour; 2, leaching; 3, softening; 4, consolidation.

Change of Colour.—Many clay deposits which are yellow, red, or brown, near the surface, are grey or greyish-black below. This is due primarily to the iron in the clay being oxidized, that is, changed from ferrous to ferric oxide. (See under iron oxide). This change in colour will extend to a variable depth below the surface, depending on the distance to which the weathering agents have penetrated the clay.

Leaching.—Clays usually contain at least some soluble materials, the commonest of which is lime carbonate. Surface waters seeping into the clay may take this lime carbonate into solution, and thus the upper layers, or portion of the deposit, may be freed from it. The lime carbonate so removed may be carried off by the infiltrating waters, or deposited in the lower layers. In a deposit of calcareous clay, therefore, the upper layers may be red burning, while the lower beds are buff-burning. This change is more common in moist than in arid climates, and at any rate, is characteristic only of highly calcareous clays. The idea held by some that lime, or even other impurities, will decrease with the distance from the surface, is erroneous.

Some clays contain considerable gypsum, often in a finely divided condition. Such clays sometimes show coarse crystalline masses of gypsum on the outcrop, due to the fact that water entering the deposit has dissolved the gypsum, and brought it to the surface in solution, where, on the evaporation of the water, it has crystallized out in large crystals. This process takes place chiefly in arid regions.

In moist climates this segregation of the gypsum usually occurs within the clay mass, and transparent plate-like masses of selenite of varying size may be formed.

The formation of concretions may be regarded as the result of leaching action.

By concretions are meant the hard, often rounded masses found in many clay or shale deposits. They are most commonly formed of iron carbonate, or hydrous iron oxide (limonite), but lime carbonate concretions are likewise not uncommon. They have probably been formed by the dissolving of iron or lime compounds in the clay by infiltrating waters, and their re-deposition around some nucleus.

Concretions of lime carbonate are found in the brick clays of the Shubenacadie valley; of iron carbonate in the Carboniferous shales; of pyrite in the Shubenacadie fireclay. Unless ground up or removed from the clay concretions may cause considerable trouble, such as splitting of the bricks in drying and burning. The lime pebbles found in some surface clays cause similar trouble, but are not to be mistaken for concretions.

Softening.—Many shales become softened on exposure to the weather. This is largely a simple process of disintegration, and usually involves little change in composition, except in the case of calcareous shales, which may show but little lime at the surface.

Consolidation.—Clays, especially those of a sandy and porous character, sometimes become hardened along certain layers, or along joint planes due to the deposition of iron oxide. This may result in the formation of a number of crusts, or hard layers in the deposit, which have to be crushed or thrown out if the clay is to be used. In some localities these are so numerous as to render an otherwise good clay worthless.

Minerals in Clay.

Owing to the fine-grained character of most clays, it is usually impossible to recognize the mineral grains in them with the naked eye, but microscopic study of clays has revealed the presence of a number of different mineral species. A few of these, such as quartz, mica, gypsum, calcite, and pyrite, are sometimes of sufficient size to be recognized at sight.

It is not necessary here to enumerate all the mineral species that have been found in clays, and only those which are of probable common occurrence need be referred to.

Kaolinite.—This mineral, which is a hydrous aluminium silicate, having the formula, Al_2O_3, $2SiO_2$, $2H_2O$, is thought by many to be present in all clays, but its existence has not in all cases been definitely proven; moreover, it is somewhat difficult to recognize even under the microscope. If the kaolinite itself is not present, it is probable that other hydrous aluminium silicates, such as pholerite, halloysite, etc., exist in the clays.

Clays of high purity no doubt contain a considerable percentage of kaolinite, the best grades of china clay running as high as 95 per cent, or even more.

Kaolinite is exceedingly refractory, and is to be regarded as a heat-resisting element, but at high temperatures it fluxes actively with silica, if the latter is present. This fact is contrary to the view formerly held by many firebrick manufacturers. It will be seen from what has been said above, that a good fireclay should be low in silicia and high in kaolinite.

Quartz.—This mineral, whose formula is SiO_2, is found in at least small quantities in nearly every clay, whether residual or sedimentary, but the grains are rarely large enough to be seen with the naked eye. They are translucent or transparent, usually of angular form in residual clays, and rounded in sedimentary ones on account of the rolling they have received while being washed along the river channel to the sea, or dashed about by the waves on the beach previous to their deposition in deeper, quiet water. The quartz grains may be colourless, but are more often coloured superficially red or yellow by iron oxide. Nodular masses of amorphous silica, termed chert or flint, are found in some clays.

Both quartz and flint are highly refractory, being fusible only at cone 35 of the Seger series, but the presence of other minerals in the clay may exert a fluxing action and cause the quartz to soften at a much lower temperature.

The amount of quartz in clays varies from under 1 per cent in some kaolins or fireclays to over 50 or 60 per cent in some very sandy brick-clays.

Feldspar.—This mineral is nearly as abundant in some clays as quartz, but, owing to the ease with which it decomposes, the grains are rarely as large. When fresh and undecomposed the grains have a bright lustre, and split off with flat surfaces or cleavages. Feldspar is slightly softer than quartz, and while the latter, as already mentioned, scratches glass, the former will not.

The fusing point of spar is about cone 9 (see Seger cones, under Fusibility), but the different species vary somewhat in their melting points. The feldspar grains may, however, begin to flux with other ingredients of the clay at a much lower temperature. (See under Alkalis).

Mica.—This is one of the few minerals in clay that can be easily detected with the naked eye, for it occurs commonly in the form of thin, scaly particles, whose bright, shining surface renders them very conspicuous, even when small. Very few clays are entirely free from mica, even in their washed condition, for, on account of the light scaly character of the mineral, it floats off with the clay particles. Some clays are highly micaceous, but such are rarely of much commercial value.

Iron Ores.—This title includes a series of iron compounds, which are sometimes grouped under the above heading, because they are precisely similar to those that serve as ores of iron when found in sufficiently concentrated form. The mineral species included under this head are: limonite ($2Fe_2O_3\ 3H_2O$); hematite (Fe_2O_3); magnetite (Fe_3O_4); siderite ($FeCO_3$).

Limonite.—This mineral occurs in clays in a variety of forms, and is often widely distributed in them, its presence when in a finely divided condition being shown by the yellow or brown colour of the material. When the clay is uniformly coloured the limonite is evenly distributed through it, sometimes forming a mere film on the surface of the grains; at other times it is collected into small rusty grains, or again forms concretionary masses of spherical or irregular shape; in still other clays it is found in the form of stringers and crusts, extending through the clay in many directions. The concretions are often especially abundant in some weathered clays. At times they take the shape of thick-walled cylindrical bodies which have apparently formed around plant roots. The beds of sandstone found in many of the sand and gravel deposits associated with some clays are caused by limonite cementing the sand grains together.

Limonite concretions can often be removed by hand-picking. If left in the clay, they cause fused blotches, which are unsightly and sometimes even cause splitting of the ware.

Limonite is most abundant in surface clays, especially those which are of sandy character or sufficiently porous to admit the oxidizing waters from the surface. It is also found quite frequently in the weathered outcrops of many shales.

Siderite, the carbonate of iron, may occur in clay in the following forms: (1) As concretionary masses known as clay-ironstones, ranging in size from a fraction of an inch to several feet in diameter. They are very abundant in some Carboniferous shales, as those at New Glasgow, and are often strung out in lines parallel with the stratification of the clay. If near the surface, the siderite concretions often change to limonite. (2) In the form of crystalline grains, scattered through the clay and rarely visible to the naked eye. (3) As a film, coating other minerals in the clay. This mineral will also change to limonite if exposed to the weather.

When iron carbonate is in a finely divided condition and evenly distributed through the clay it may give it a blue or slate-grey colour.

Siderite may be present in some surface clays, but it is probably of greatest importance in shales, notably those associated with coal seams, and may occur in either finely divided (disseminated) or concretionary form.

Pyrite[1] (FeS_2=Fe 46·6 per cent, S 53·4 per cent).—This mineral, which is not uncommon in some clays, can be often seen by the naked eye, and is known to the clay miners in some districts as sulphur. It has a yellow colour, metallic lustre, and occurs in large lumps, small grains, or cubes, or again in flat rosette-like forms. Not infrequently it is formed on or around lumps of lignite, showing quite clearly that the carbonaceous matter has reduced some iron sulphate present to sulphide. The only Nova Scotia clays in which it was found were those at Shubenacadie, and in the Musquodoboit valley

When exposed to the weather, pyrite alters rather easily, first to the sulphate of iron, and then to limonite. Clays containing pyrite are not, as a rule, desired by the clay-worker, and in mining the pyritic material is rejected.

Pyrite may be found in almost any clay or shale, but owing to the ease with which it is converted into limonite its formation or permanence in surface clays is rare.

Calcite ($CaCO_3$=CaO 56·00 per cent, CO_2 44·0 per cent).—This mineral, when abundant, is found chiefly in clays of recent geologi-

[1] In some clays this may be marcasite, the orthorhombic form of FeS_2.

cal age, but some shales also contain considerable quantities of it. It can be easily detected, for it dissolves rapidly in weak acids, and effervesces violently upon the the application of a drop of muriatic acid or even vinegar. It is rarely present in grains large enough to be seen with the naked eye, but has been detected with the microscope.

In some clays, calcite, as well as some other minerals, may form concretions. The brick clay found on the Mira river contains lime carbonate in a finely divided form, but not in sufficient quantities to make the clay burn buff coloured.

Gypsum ($CaSO_4$, $2H_2O$=CaO 32·6 per cent, SO_3 46·5 per cent, H_2O 20·9 per cent).—It is doubtful whether this mineral is widely distributed in clays, but it is true that some deposits contain large quantities of it. It may occur in a finely divided condition, or in the form of crystals, plates, or fibrous masses of selenite. Its softness, pearly lustre, and transparency render its identification easy when the pieces are of sufficient size to be seen with the naked eye. When heated to a temperature of 250° F, (121° C) the gypsum loses its water of combination, and when burned to a still higher temperature the sulphuric acid passes off. The lower Carboniferous shales of Nova Scotia sometimes carry nodules or plates of gypsum.

Chemical Analysis of Clays.

There are two methods of quantitatively analyzing clays. One of these is termed the ultimate analysis, the other is known as the rational analysis.

The Ultimate Analysis.—In this method of analysis, which is the one usually employed, the various ingredients of a clay are considered to exist as oxides, although they may really be present in much more complex forms. Thus, for example, calcium carbonate ($CaCO_3$), if it were present, is not expressed as such, but instead it is considered as broken up into carbon dioxide (CO_2) and lime (CaO), with the percentage of each given separately. The sum of these two percentages would, however, be equal to the amount of lime carbonate present.

Altogether too much weight is attached to the chemical analysis by those unfamiliar with the properties and behaviour of clay, and many wholly unwarranted deductions are made from it. It is true that the chemical analysis indicates the percentage of different substances present in the clay, and that the effect or action of these substances is understood in a fairly definite way, as indicated on pages 123 to 125, but their effectiveness depends to a large degree on their uniformity of distribution, and this is not indicated by the analysis.

Moreover, the ultimate analysis gives us little or no information regarding certain physical properties, such as the plasticity, degree of shrinkage in drying and burning, density after burning, etc.

It is, therefore, more or less absurd to conclude from a chemical analysis alone that a clay could be used for certain classes of ware.

But, regarding the matter from a fair and conservative standpoint, it would seem that the following inferences may be made from an ultimate chemical analysis, provided the clay is of fine-grained uniform texture, and the elements in it evenly distributed, and not forgetting that there may be numerous exceptions to every case:—

(1) The purity of the clay, showing the proportions of silica, alumina, combined water, and fluxing impurities present. High grade clays often show a percentage of silica, alumina, and chemically combined water, approaching quite closely to kaolinite.

(2) The approximate refractoriness of a clay; for other things being equal, a clay with high total fluxes is commonly less refractory than one with low total fluxes. Several factors, it must be remembered, such as texture, irregularity of distribution of the constituents, and condition of kiln atmosphere may affect the result.

(3) The colour to which the clay burns. This must be judged with extreme caution. Assuming the constituents to be evenly distributed, then a clay with 1 per cent or less of ferric oxide is likely to burn pure white, but at high temperatures titanium, if present, appears to produce discoloration. One with 2 to 3 per cent ferric oxide is likely to burn buff, and one with more than this will probably burn red, if there is not an excess of lime or alumina present.

(4) Excess of silica. A high percentage of silica (80 to 90 per cent) may indicate a sandy clay, and possibly one of low shrinkage. but it does not necessarily indicate low plasticity. High silica in a fireclay usually shows moderate refractoriness, provided it is evenly distributed.

(5) Carbon. This should be determined, as it causes trouble in burning if present to the extent of several per cent, requiring thor-

ough oxydation in firing before the clay is allowed to pass to the vitrification stage.

(6) Sulphur trioxide. Since this may be the cause of swelling in improperly burned wares, and also indicate the presence of soluble sulphates, it should also be determined.

(7) The presence of a high percentage of lime carbonate shows the clay to be of calcareous character, and if this is evenly distributed it is likely to be of buff-burning character, with low refractoriness, and a narrow margin between vitrification and viscosity.

(8) Titanium dioxide should be determined in fireclays, as 2 or 3 per cent may reduce the refractoriness to an appreciable degree.

Yet, though the above deductions appear to yield much information, the conclusions are not definite, and, as mentioned above, we are still left in the dark regarding many important physical properties. The physical tests of a clay are, therefore, of vastly more importance and practical value, and it is for this reason that so few chemical analyses appear in this report.

The Rational Analysis.—In this method of analysis an attempt is made to determine the compounds actually present in a clay, such as kaolinite, quartz, feldspar, etc. The methods thus far developed are unsatisfactory.

Substances present in Clay and their effect.

Silica[1].—This is present in clay in two different forms, namely, uncombined as silica or quartz, and in silicates, of which there are several. Of these, one of the most important is the mineral kaolinite, which probably occurs in all clays, and is termed the clay base, or clay substance. The other silicates include feldspar, mica, glauconite, hornblende, garnet, etc. These two modes of occurrence of silica, however, are not always distinguished in the ultimate analysis of a clay, but when this is done they are commonly designated as 'free' and 'combined' silica, the former referring to all silica except that contained in the kaolinite, which is indicated by the latter term. This is an unfortunate custom, for the silica in silicates is, properly speaking, combined silica, just as much as that contained in kaolinite. A better practice is to use the term sand, to include quartz and silicate minerals other than kaolinite, which are sup-

[1] See also description of the minerals quartz, feldspar, kaolinite, and mica, above.

posedly not decomposable by sulphuric acid. In most analyses, however, the silica from both groups of minerals is expressed collectively as total silica.

The percentage of both quartz and total silica found in clays varies between wide limits.

The free silica or quartz is one of the commonest constituents of clay, and ranges in size from particles sufficiently large to be visible to the eye down to the smallest grains of silt.

Sand (quartz and silicates) is an important anti-shrinkage agent, which greatly diminishes the air shrinkage, plasticity, and tensile strength of clay, its effect in this respect increasing with the coarseness of the material; clays containing a high percentage of very finely divided sand (silt) may absorb considerable water in mixing, but show a low air shrinkage. The brickmaker recognizes the value of the effects mentioned above, and adds sand or loam to his clay, and the potter brings about similar results in his mixture by the use of ground flint. If too much sand is added to the brick mixture it makes the product too porous, and soft.

It is thought by some that because of the refractoriness of quartz its addition to any clay will raise its fusion point, but this is true only of those clays containing a high percentage of common fluxes and silica, and which are burned at low temperatures. Its effect on highly aluminous low flux clays reduces their refractoriness.

In considering the effects of sand in the burning of clays, it must first be stated that the quartz and silicates fuse at different temperatures. A very sandy clay will, therefore, have a low fire shrinkage, as long as none of the sand-grains fuse, but when fusion begins a shrinkage of the mass occurs. We should, therefore, expect a low fire shrinkage to continue to a higher temperature in a clay whose sand-grains are refractory.

Iron Oxide: Sources of Iron Oxide in Clays.—Iron oxide is one of the commonest ingredients of clay, and a number of different mineral species may serve as sources of it, the most important of which are grouped below:—

Hydrous oxide, limonite; oxides, hematite, magnetite; silicates, biotite, glauconite (greensand), hornblende, garnet, etc.; sulphides, pyrite; carbonates, siderite; sulphate, melanterite.

In some, such as the oxides, the iron is combined only with oxygen, and is better prepared to enter into chemical combination with other elements in the clay when fusion begins. In the case of the sulphides and carbonate, on the contrary, the volatile elements, namely, the sulphuric-acid gas of the pyrite, and the carbonic-acid gas of the siderite, have to be driven off before the iron contained in them is ready to enter into similar union. In the silicates the iron is chemically combined with silica and several bases, forming mixtures of rather complex composition, and all of them of low fusibility, particularly the glauconite. Several of these silicates are easily decomposed by the action of the weather, and the iron oxide which they contain combines with water to form limonite. This is usually in a finely divided condition, so that its colouring action is quite effective.

Effects of Iron Compounds.—Iron is the great colouring agent of both burned and unburned clays. It may also serve as a flux, and even affect the absorption and shrinkage of the material.

Colouring Action of Iron in Unburned Clay.—Many clays show a yellow or brown coloration due to the presence of limonite, and a red colouration due to hematite.

Colouring Action of Iron Oxide on Burned Clay.—All of the iron ores will, in burning, change to the red or ferric oxide, provided a sufficient supply of oxygen is able to enter the pores of the clay before it is vitrified; if vitrification occurs the iron oxide enters into the formation of silicates of complex composition. The colour and depth of shade produced by the iron will, however, depend on, (1) the amount of iron in the clay; (2) the temperature of burning; (3) condition of the iron oxide; and (4) the condition of the kiln atmosphere.

Clay free from iron oxide burns white. If a small quantity, say 1 per cent, is present, a slightly yellowish tinge may be imparted to the burned material, but an increase in the iron content to 2 or 3 per cent often produces a buff product; while 4 or 5 per cent of iron oxide in many cases makes the clay burn red. There seem, however, to be not a few exceptions to the above statements. Thus, we find that the white-burning clays carry from a few hundredths per cent to over 1 per cent of iron oxide, the more ferruginous containing more iron than the purer grades of buff-burning clays. Again, among the buff-burning clays we find some with an iron oxide content of 4 or 5 per cent, an amount equal to that contained in some red-burning ones.

The facts would, therefore, seem to indicate that the colour of the burned clay is not influenced solely by the quantity of iron present.

The brilliancy of the colour appears to be influenced by the texture, as the more sandy clays can be heated to a higher temperature, without destruction of the red colour, than the more aluminous ones. Alkalis also appear to diminish the brightness of the iron coloration.

Among the oxides of iron two kinds are recognized, known respectively as the ferrous oxide (FeO), and ferric oxide (Fe_2O_3). In the former we see one part of iron united with oxygen, while in the latter one part of iron is combined with one and one-half parts of oxygen. The ferric oxide, therefore, contains more oxygen per unit of iron than the ferrous salt, and represents a higher stage of oxidation. In the limonite and hematite the iron is in the ferric form, representing a higher stage of oxidation. In magnetite both ferrous and ferric iron are present, but in siderite the ferrous iron alone occurs. In the ultimate analysis the iron is usually determined as ferric oxide, no effort being made to find out the quantity present in the ferrous form, although if there is any reason to suspect that much of the latter exists it should be determined. Iron passes rather readily from the ferric to the ferrous form. It also oxidizes easily unless carbon and sulphur are present, in which case its oxidation is not possible until these two substances have been oxidized. Indeed they are sometimes supplied with oxygen at the expense of the iron, which may be left in a ferrous, magnetic, or even spongy, metallic condition; so if there is a deficit of oxygen in the inside of the kiln the iron does not get enough oxygen, and the ferrous compound results, but the latter changes rapidly to the ferric condition if sufficient air carrying oxygen is admitted. If, however, the oxidation of the iron does not begin until the clay has become so dense as to prevent free circulation of the air through it, then it may form ferrous silicates, which impart black or dark colours to the clay.

Moreover, in the burning of ferruginous clays it is usually desirable to get the iron thoroughly oxidized to prevent trouble in the later stages of burning. To accomplish this the iron must be freed of any sulphur or carbon dioxide which may be combined with it, and other volatile or combustible elements in the clay must be driven off, so as to allow the oxidizing gases to enter the clay and unite with any ferrous iron that may be present.

Sulphide of iron (pyrite) loses half its sulphur at a red heat, and the balance will, under oxidizing conditions, pass off probably by 900° C, while siderite or ferrous carbonate loses its carbon dioxide between 400° and 500° C; magnesium carbonate and calcium carbonate lose their CO_2 at about 500° C, and 800° to 900° C respectively. Carbonaceous matter or sulphur, if present, must also be carefully burned off. If the clay contains much volatile or combustible matter the burning must proceed slowly below 1000° C, in order to remove it and allow the iron to get oxidized while the clay is still porous.

After oxidation the clays will show a more brilliant iron colour than they do at the end of the dehydration period. They are also harder, and show a slight decrease in volume.

If the clay has been improperly oxidized it shows later when vitrification is reached, by the dark ferrous silicate cores in the centre of the brick. This may form, however, without the development of any swelling. When swelling does accompany the formation of this black core it is to be traced to sulphur.

Fine-grained clays are more difficult to oxidize than coarse-grained, because of the small size of their pores, and grog is, therefore, added at times to open the grain of the material.

Since the stage of oxidization of the iron is dependent on the quantity of air it receives during burning, the condition of the kiln atmosphere is of great importance. If there is a deficiency of oxygen in the kiln, so that the iron oxide, if present, is reduced to the ferrous condition, the fire is said to be reducing. If, on the contrary, there is an excess of oxygen, so that ferric oxides are formed, the fire is said to be oxidizing. These various conditions are often used by the manufacturer to produce certain shades of colour effects in his ware. Thus, for example, the manufacturer of flashed brick produces the beautiful shading on the surface of his product by having a reducing atmosphere in his kiln, followed by an oxidizing one. The potter aims to reduce the yellow tint in his white ware by cooling the kiln as quickly as possible to prevent the iron from oxidizing.

In those clays which are of grey or black colour the iron may be present in both the ferrous and ferric form; the quantity present in that from several localities is shown below:—

	Field Number.				
	41.	42.	47.	91.	94.
Fe_2O_3	1·56	1·96	1·34	2·46	1·91
FeO	4·97	3·19	6·12	2·29	3·61

41. Shale from Standard Drain Pipe Works, New Glasgow.
42. Lower shale, Brooks' brickyard, New Glasgow.
47. Shale, Intercolonial Coal Company, Westville.
91. Shale under coal seam, King mine, Minto, N.B.
94. Shale under coal, Canadian Coal Company, Salmon bay, N.B.

All analysed by H. A. Leverin, analyst, Mines Branch.

As these clays and shales all contain small amounts of sulphur and carbon, it is highly important to fire the material slowly, in order to burn off the carbon, and as much sulphur as possible, as well as to cause the large amount of ferrous iron to become oxidized.

Fluxing Action of Iron Oxide.—Iron oxide is a fluxing impurity, lowering the fusing point of the clay, and this effect will, in general, be more pronounced if the iron is in a ferrous condition, or if silica is present.

Effect of Lime Carbonate on Clay.—Lime is probably most effective in the form of the carbonate, and if finely divided is an active flux. When clays containing it are burned, they not only lose their chemically combined water but also their carbon dioxide; but while the water of hydration passes off between 450° C (842° F) and 600° C, (1112° F) the carbon dioxide (CO_2) does not seem to go off until between 600° C, (1112° F) and 725° C, (1562° F). In fact, it more probably passes off between 850° C (1562° F), and 900° C, (1652° F). The result of driving off this gas, in addition to the chemically combined water, is to leave calcareous clays more porous than other clays up to the beginning of fusion.

If the burning is carried only far enough to drive off the carbonic-acid gas, the result will be that the quicklime thus formed will absorb moisture from the air and slake. No injury may result from this if the lime is in a finely divided condition and uniformly distributed through the brick, but if, on the contrary, it is present in the form of lumps, the slaking and accompanying swelling of these may split the brick.

Limestone pebbles, if present in the clay, should be either removed, if this can be done cheaply, or crushed before the clay is moulded.

Effect of Gypsum.—Gypsum in the clay has probably often been formed by sulphuric acid, liberated by the decomposition of iron pyrite, acting on lime carbonate. Lime, if present in the form of gypsum, seems to behave differently from lime in the form of carbonate, although few clays contain large percentages of it.

If present in grains or lumps these burn to a white powder, but unlike lime do not slake and swell.

Magnesia.—Magnesia (MgO) rarely occurs in clay in larger quantities than 1 per cent. When present, its source may be any one of several classes of compounds, that is, silicates, carbonates, and sulphates.

It is to be regarded as a flux, but perhaps not as active a one as lime. It is always present in a finely divided form.

Alkalis.—The alkalis commonly present in clays include potash (K_2O), soda (Na_2O), and ammonia (NH_3). There are other alkalis, but they are probably of rare occurrence.

Several common minerals may serve as sources of the alkalis. Feldspar may supply either potash or soda. Muscovite, the white mica, contains potash. Greensand, or glauconite, contains potash. Other minerals, such as hornblende or garnet, might serve as sources of the alkalis, but are unimportant, as they are rarely present in clays in large quantities.

The alkalis are strong fluxes, but they are rarely present in large amounts.

Titanium.—Titanium is an element which is found in several minerals, some of which are more common in clays than is usually imagined, although they appear rare because they are seldom found in large quantities. The two commonest of these are rutile and ilmenite. So far as known, neither of these is ever found in clays in sufficiently large grains to be visible to the naked eye, so that a microscopic examination would be necessary to identify them. Although titanium is such a common constituent of clay, it is rarely shown in an analysis, because its determination by chemical methods is attended with more or less difficulty and is rarely carried out. In the ordinary process of chemical analysis it is usually included with the alumina.

Titanium may be regarded as a flux, but since the quantity present in most clays is usually small, it seems to operate mainly at high temperatures. Thus, a clay whose fusion point lay between con 34 (1810° C) and 35 (1830° C), fused at cone 32 (1770° C), when 5 per cent of titanium oxide was mixed with it.

WATER IN CLAY.

Under this head are included two kinds of water: (1) mechanically combined water or moisture; (2) chemically combined water.

Mechanically Combined Water.—The mechanically combined water is that which is held in the pores of the clay by capillary action, and fills all the spaces between the clay grains. When these are all small, the clay may absorb and retain a large quantity, because each interspace acts like a capillary tube. If the spaces exceed a certain size, they will not longer hold the moisture by capillary action, and the water, if poured on the clay, would fast drain away. The fine-grained clays, for these reasons, show high powers of absorption and retention, while coarse, sandy clays or sands represent a condition of minimum absorption. This same phenomenon shows itself in the amount of water required for tempering a clay. Thus, a very coarse sandy mixture from one deposit may require only 15 per cent of water, while a very fat one from another deposit may take 45 per cent of water. It is not the highly aluminous ones, however, that always absorb the most water.

The total quantity of water found in different clays varies exceedingly. In some air dried clays it may be as low as 0·5 per cent, while in those freshly taken from the bank it may reach 30 to 40 per cent without the clay being very soft.

Clay is very hygroscopic, and when thoroughly dry greedily absorbs moisture from the atmosphere; indeed it may absorb as much as 10 per cent of its weight.

Water held mechanically in a clay will pass off partly by evaporation in air, but can all be driven off by heating the clay to 100° C, (212° F). The evaporation of the mechanical water is accompanied by a shrinkage of the mass, which ceases, however, when the particles have all come in contact, and before all the moisture is driven off, because some remains in the pores of the clay. This last portion is driven off during the early stages of burning. The shrinkage that takes place when the mechanical water is driven off varies, ranging from 1 per cent, or less, in very sandy clays up to 10 or 12 per cent in very plastic ones.

Since most clays having a high absorption shrink a large amount in drying, there is often danger of their cracking, especially if rapidly dried, owing to the rapid escape of the water vapour. Mechanical water may hurt the clay in other ways. Thus, if the material contains any mineral compounds which are soluble in water, the latter, when added to the clay, will dissolve a portion of them at least. During the drying of the brick the water rises to the surface to evaporate, and brings out the compounds in solution, leaving them behind when it vaporizes. It may also help the fire gases to act on certain elements of the clay, a point explained under "Burning."

Chemically Combined Water.—Chemically combined water, as its name indicates, is that which exists in the clay in chemical combination with other elements, and which, in most cases, can be driven out only at a temperature ranging from 400° C, (752° F), to 600° C (1112° F). This combined water may be derived from several minerals, such as kaolinite, which contains nearly 14 per cent white mica or muscovite with 4 to 5½ per cent, and limonite with 14·5 per cent. Unless a clay contains considerable limonite or hydrous silica, the percentage of combined water is commonly about one-third the percentage of alumina found in the clay. In pure, or nearly pure kaolin, there is nearly 14 per cent, and other clays contain varying amounts, ranging from this down to 3 or 4 per cent, the latter being the quantity found in some very sandy clays. The loss of its combined water is accompanied by a slight but variable shrinkage in the clay, which reaches its maximum some time after all the volatile matters have been driven off.

In many clay analyses the chemically combined water is determined as loss on ignition, which is incorrect if the clay contains carbon dioxide, sulphur trioxide, or organic matter, all of which are driven off, in part at least, at a dull red heat.

EFFECTS OF CARBON IN CLAY.

Carbon may be present in clay in the form of: (1) vegetable matter; (2) asphaltic carbon, and (3) fixed carbon. Only the second and third of the groups mentioned need be considered. The first alone causes trouble when it occurs in the form of sticks or thick roots, and has to be screened out. It is, therefore, not included in what follows.

Carbonaceous matter often serves as a strong colouring agent of raw clays, tinging them grey, bluish-grey, or black. Indeed, so strong may this be that it masks the effect of other colouring agents, such as iron. In fact, two clays coloured black might burn red and white respectively, because one had much iron and the other none, and yet, owing to their black colour, this could not be foretold with definiteness.

Asphaltic carbon, aside from its colouring action, often causes much trouble in burning, causing black cores, or even swelling and fusing of the brick. More than this, it may keep the iron in a ferrous condition and prevent the development of the best colour effects in the ware.

The reason for this is due to several causes.

Carbon has a strong affinity for oxygen, much stronger than that of iron, therefore as long as it remains in the clay it will monopolize the supply of oxygen and keep the iron in a ferrous condition, the form in which much of it is, in grey or black clays and shales. Now, in burning a clay, one of the aims of the clay worker is to get the iron into a ferric condition, so as to fully develop its colouring properties and prevent other troubles. As long as any carbonaceous matter remains the oxidation of the iron is prevented or retarded, and consequently the carbon must be burned out.

The experiments of Orton and Griffin have shown that between 800° and 900° C is the best temperature interval for burning off the carbon, as below this its oxidation does not proceed as rapidly, and above this there is danger of vitrification beginning, and the oxidation being stopped.

The method of procedure would, therefore, be to drive all moisture out of the clay first, then raise the heat as rapidly as possible to a temperature between 800° and 900° C, and hold it there until the ware no longer shows a black core denoting ferrous iron.

In order to burn off the carbon and oxidize the iron, air supplying oxygen must be drawn into the kiln during burning, for the gases of combustion from the fuel will supply none. Oxidation may be accelerated by increasing the amount of air entering the kiln, and by reducing the density of the clay as much as possible. In case this is not done, and the pores of the clay close up before all the carbon is burned off, it also interferes with the expulsion of sulphur present which may result in a swelling of the clay. This may be even followed by complete fusion of the interior of the mass, caused by the formation of an easily fusible ferrous silicate. When the carbon is all burned off the iron has a chance to oxidize. If the clay contains much asphaltic carbon the oxidation must be carried on with as little air as possible, otherwise the heat generated by the burning hydrocarbons may be so intense as to vitrify the ware before the oxidation is completed.

Since dense clays are more difficult to oxidize than those which are porous, the process of manufacture may also influence the results, and in this connexion it has been found that bricks made by the soft mud process are most rapidly oxidized, followed by either the stiff mud or dry-press (there being no difference between the two), and lastly by the semi-dry-press.

Effect of Water on Black Coring.—It is often stated by brickmakers that black cores are caused by the brick being set too wet. This is not strictly true, and the relation is a very indirect one. While carbon burns off most rapidly between the temperatures of 800° and 900° C, it also passes off somewhat at much lower temperatures. If the brick is set wet it requires so much more heat in the early stages of firing to drive out or evaporate the water that other changes, such as the oxidation of the carbon, will be retarded, and brick begins to vitrify before the process is completed.

SULPHUR.

Many clays contain at least a trace of sulphur, and some show appreciable quantities, but determinations of it are rarely made, unless the clay is to be employed for Portland cement manufacture. As can be seen from the experiments of Seger, and more especially Orton and Staley, it may cause serious trouble, and should always be determined in the analysis of a clay.

Sulphur might be present in a clay, as:—

(1) Sulphate, such as gypsum (CSO_4, $2H_2O$), epsomite ($MgSO_4$, $7H_2O$), or melanterite ($FeSO_4$, $7H_2O$).

(2) Sulphide, as pyrite (FeS_2) or marcasite (FeS_2).

Few investigators have, however, given much attention to the matter.

From experiments on a Columbus black shale, running high in carbon, ferrous iron, and sulphur, Orton and Staley adopted the series of conclusions given below:—

The shale contained an average of 2·997 per cent of total sulphur, expressed as the element, of which 0·76 per cent was contained in soluble sulphates, and 2·235 in sulphides.

They conclude:—

(1) Both sulphates and sulphides experience rapid diminution by dissociation, in that portion of the burn up to 800° C, in those portions of the ware which get air freely. This loss of sulphur may amount to two-thirds or three-fourths of the amount originally present.

(2) Both sulphates and sulphides experience a further slow diminution by dissociation or oxidation, beginning at 800° C, and continuing as long as the clay structure remains porous and permeable to air. The loss of sulphur may amount to 90 per cent or more of the initial sulphur content at the end of the period, but it proceeds increasingly slowly, and would probably never become complete.

(3) In the interior portions of the clay, to which air cannot readily penetrate, the loss of sulphur may be less, and if there are any bases, such as FeO, CaO, or MgO present, with which the sulphur may combine, the sulphur is not likely to be expelled.

(4) Carbon, even in small quantities, interferes strongly with the expulsion of sulphur, which does not pass off to any extent until after the carbon goes. The clay may, therefore, have become too dense by that time for the oxidation of the sulphur to proceed, so that the carbon has virtually prevented its escape.

(5) Sulphur retained in the clay in any form, and from any cause, is not likely to cause physical disturbances in the clay until a fairly complete degree of vitrification is reached.

(6) When a clay reaches a dense vitrified condition it proceeds normally, after a longer or shorter interval, to become less dense. by reason of the development of multitudes of minute vesicles in

the viscous body; this process is progressive and in the end the body becomes spongy and worthless.

(7) The length of this period of dense vitrification is much shortened, and in some cases practically abolished, by the presence of sulphur compounds, which break down and evolve gases copiously, producing a prematurely spongy body.

(8) The cause of this gas evolution is chiefly the dissociation of sulphides and sulphates by silicic acid, which becomes increasingly active as the temperature rises, and appropriates the bases formerly combined with the sulphur.

(9) In clays of low sulphur content, and of favourable structure for oxidation, the amount of sulphur left in the clay at vitrification is very small. Hence the period of good structure is long, the vesicular structure develops slowly, and the clay is said to stand over-firing well.

(10) In clays of high sulphur content, or of dense structure unfavourable for oxidation, or of high content of iron and carbon, the escape of the sulphur is prevented, the clay has a very narrow period of usefulness, or none at all, and the vesicular structure becomes enormously exaggerated.

(11) While this premature and exaggerated swelling from sulphur may in aggravated cases occur in well oxidized clays, it is practically certain to occur where clays containing a partly oxidized core are allowed to reach the vitrification period.

(12) This breaking down of sulphur compounds by silicic acid is the chief or common cause of the premature swelling of black coloured clays, and the occasional cause of sudden and severe swelling of properly oxidized clay wares.

(13) The proper way to avoid the effects of sulphur in vitrifying clay bodies is to apply a deliberate and complete oxidation treatment while the clay remains porous. This will rid the clay of the greater part of the sulphur, and will prevent sudden or premature slagging of the clay by ferrous oxide, if it is true that ferrous oxide has such a tendency, and will thus avoid, so far as possible, the conditions which favour swelling. Clays which still give trouble from swelling after this treatment must be regarded as bad clays.

REACTIONS INVOLVED IN EXPULSION OF SULPHUR.

These may be expressed briefly as follows, the simpler and most probable ones only being given:—

Pyrite heated to 400° C, gives FeS_2 + heat=FeS + S.

The S in the air catches fire and burns to SO_2 or SO_3, but if liberated in a clay soft and spongy by heat it may attack FeO, CaO, or MgO. However, most of it probably escapes.

FeS exposed to oxidizing conditions might oxidize to ferrous sulphate, but further heating to 550-650° C breaks it up, leaving FeO, the latter in an oxidizing atmosphere changing to Fe_2O_3.

Calcium sulphate also breaks down, but at higher temperatures than ferrous sulphate and less completely. The action of carbon in restraining the liberation of sulphur is explained as follows:—

$$FeCO_3 + 425° \text{ C} = FeO + CO_2.$$

If, now, free sulphur is liberated in the immediate vicinity,

$$FeO + C + S = FeS + CO.$$

This ferrous sulphide cannot be broken up by heat alone, but only by roasting in air, or interaction with silicic acid, for as pointed out by Seger, silicic acid at high temperatures has the power of displacing all other common acids, and combining with their bases to form silicates. It thus has the power to replace sulphuric acid, and the sulphur of sulphides. He found that a bisilicate glass mixture, saturated with sulphates, showed 4 per cent sulphuric acid; while the same glass, with one more molecule of silica added and melted at the same temperature and under the same conditions, contained only 2 per cent sulphuric acid. Now, in raising the temperature of burning, the fusing matrix of a clay becomes more siliceous, resulting in the expulsion of sulphur.

SOLUBLE SALTS.

Origin.—It has been pointed out, in explaining the origin of clay, that in the decomposition of mineral grains in clay soluble compounds are often formed. During the drying of the clay the moisture brings these to the surface, and leaves them there when it evaporates, thus forming a scum on the air-dried ware, and sometimes a white coating on the clay after it is burned. Those found in the clay are commonly sulphates of lime, iron, or alkalis, and their formation is generally due to the decomposition of the iron pyrite frequently contained in the clay. A much greater quantity of soluble sulphates will be formed if the pyrite is in a finely divided condition and evenly distributed through the clay, but soluble compounds may also be formed without the aid of pyrite, as when carbonates are set free by the decomposition of silicates, such as feldspar. When the soluble compounds have formed in the green clay their presence can often be detected by spreading the dug clay out to weather, which will result in their forming a crust on the surface of the mass.

Their formation does not cease, however, when they are removed from the ground, for in some cases fresh pyrite grains remain in the clay after mixing, and if the clay is stored in a moist place these may decompose, yielding an additional amount of soluble material. One means of preventing this would seem to be the use of the clay as soon as possible after mixing.

In some cases soluble sulphates may be even introduced into the clay by the water used for mixing, for distilled water is the only kind that is free from soluble salts. All well and spring waters contain some at least, and if these flow or drain from clays or rocks containing any pyrite they are almost sure to contain soluble salts. Those flowing from lime rocks are usually hard, on account ot the lime carbonate which they contain. Still another source of soluble salts in raw clay lies in some of the artificial colouring materials which are sometimes used.

Soluble salts brought out in the drying of the clay are termed dryer-white, but do not differ in composition from those formed during burning and known as kiln-white.

Soluble sulphates are sometimes formed in burning, through the use of sulphurous fuel, that is, coal containing more or less iron pyrite. When the coal is burned part of the sulphur in the pyrite is expelled, and, uniting with the oxygen, forms sulphuric-acid gas (SO_3). This passes through the kiln, and, if it comes in contact with carbonates in the clay, converts them into sulphates, because some substances, such as lime (CaO), have a stronger affinity for sulphur trioxide (SO_3) than for carbon dioxide (CO_2).

It frequently happens that clay products come from the kiln apparently free from any superficial discoloration or coating, but develop one later on if subjected to moisture. This type of coating is known as wall-white. It may be derived from salts formed within the body of the ware during burning, and subsequently brought to the surface by the evaporation of moisture absorbed during rainy weather, or it may come from the mortar, either by the direct introduction of soluble salts from it, or by reaction between carbonates of magnesium, potassium, and sodium of the mortar, with calcium sulphate in the brick. This gives calcium carbonate.

Mäckler found that, in a series of fifty bricks examined, the sum of the sulphates of lime, magnesium, and alkalies varied from ·0134 per cent to ·7668 per cent.

The coatings thus far mentioned are all white in colour. In some instances, however, the product becomes covered with a yellow or green stain, which is caused either by the growth of vegetable matter on the surface of the bricks, or by soluble compounds of the rare element vanadium.

Quantity of Soluble Salts in Clays.—The amount of soluble salts present in a clay is never very great, but less than 0·1 per cent is often sufficient to produce a white incrustation.

Prevention of Soluble Salts.—The methods of prevention that have been suggested for dryer-white and kiln-white are:—

(1) Use of the clay in its unweathered condition, or before the soluble salts have time to form.

(2) Use of the clay in a thoroughly weathered condition, thus permitting removal of soluble salts by leaching.

(3) Change of the soluble salts into a harmless form by precipitation with barium compounds.

(4) Prevention of concentration of salts on surface of brick by rapid firing.

(5) Removal of whitewash in the kiln by using a reducing flame.

(6) Coating the brick with some combustible substance, as wheat flour, or coal tar, which burns away with a strong reducing action and removes the whitewash.

Referring in more detail to (3), it may be explained that the substance commonly added is either barium chloride or barium carbonate. When barium salts come in contact with soluble sulphates, barium sulphate is formed, a combination which is insoluble in water. This is expressed by the first of the following chemical reactions, if barium is used, and by the second, if barium chloride is employed:—

(1) $CaSO_4+BaCO_3=CaCO_3+BaSO_4$.

(2) $CaSO_4+BaCl_2=CaCl_2+BaSO_4$.

We thus see that in both cases we get compounds which are insoluble, or nearly so. If soluble sodium compounds are present, the addition of barium carbonate, or barium chloride, will form either sodium carbonate or sodium chloride (common salt), but since both of these are easily soluble in water they can be washed off without much trouble.

Method of use.—As carbonate of barium is insoluble in water; in order to make it thoroughly and uniformly effective, it should be used in a finely powdered condition, and distributed through the clay as thoroughly as possible, because it will only act where it comes into immediate contact with the soluble sulphates. While only a small quantity of barium is necessary, it is desirable to use somewhat more than is actually required.

According to Gerlach, a clay containing 0·1 per cent sulphate of lime, which is the same as 0·4 grams per pound, would need 0·6 of a gram of barium carbonate per pound of clay. For safety, however, 6 or 7 grams should be added to every pound of clay. This would be about 100 pounds for every thousand bricks, based on the supposition that a green brick weighs 7 pounds. As a pound of barium carbonate costs about 2½ cents, the amount required for 1,000 bricks would be $2.50. It is cheaper to use barium chloride, for the reason that the salt is soluble in water, and hence can be distributed more evenly with the use of a smaller quantity; the chemical reaction also takes place much more rapidly when it is used. There is this objection to it, however, that as near the theoretic amount as possible must be used; for if any remains in the clay unchanged, that is, without having reacted with the soluble salts, it may of itself form an incrustation.

In the case of a clay containing 0·1 per cent calcium sulphate it would require 26 pounds of barium chloride per thousand bricks, and this, at 2½ cents a pound, would mean an outlay of 65 cents. With the barium-chloride treatment, chloride of lime is formed, but this is decomposed in burning.

Since, in drying moulded-clay objects, the evaporation is greatest from the edges and corners of the ware, the incrustations may be heaviest at these points, but the more rapidly the water is evaporated the less will be the quantity of soluble salts deposited on the surface. Incrustations which appear during drying are found more commonly on bricks made from very plastic clays, which, owing to their density, do not allow the water to evaporate quickly.

Remedy for Wall-white.—This is more difficult, but consists primarily in preventing entrance of moisture to the walls. It is suggested to make the walls as impervious as possible by the use of well-burned brick, and proper drainage and waterproofing of the foundations. If the efflorescence appears, the walls may be painted so as to cover the efflorescence, but it may then peel off in damp spots. A coat of paraffin or linseed oil will conceal the white coating somewhat, but also darken the brick. They should also be made waterproof if possible.

PLASTICITY.

Definition.—Plasticity is probably by far the most important property of clay, lacking which it would be of comparatively little value for the manufacture of clay products. Seger has defined it as the property which solid bodies show of absorbing and holding a liquid in their pores, and forming a mass which can be pressed or kneaded into any desired shape, which it retains when the pressure ceases, and, on the withdrawal of the water, changes to a hard mass. The term hard, of course, refers to its hardness as compared with its wet condition, for some air-dried clays are rather soft.

TENSILE STRENGTH.

Definition.—The tensile strength of a clay is the resistance which it offers to rupture or being pulled apart when air-dried.

Practical Bearing.—The tensile strength is an important property, and has a practical bearing on problems connected with the handling, moulding, and drying of the ware, since a high strength enables the clay to withstand the shocks and strains of handling. Through it, also, the clay is able to carry a large quantity of non-plastic material, such as flint or feldspar, ground bricks, etc.

Relation to Plasticity.—Although it was formerly believed by many that tensile strength and plasticity were closely related, this view is no longer generally accepted. High tensile strength and high plasticity often go together, but a clay low in tensile strength may have high plasticity, and vice versa.

Measurement of Tensile Strength.—The tensile strength is measured by moulding the thoroughly kneaded clay into briquettes, of the same shape and size as those made in cement testing, and, when thoroughly air-dried, pulling them apart in a suitable testing machine.

SHRINKAGE.

All clays shrink in drying and burning, the former loss being termed the air shrinkage, and the latter the fire shrinkage.

Air Shrinkage.—In a clay which is perfectly dry all the grains are in contact, but between them there will be a variable amount of pore space, depending on the texture of the clay. The volume of this pore space is indicated somewhat by the quantity of water that will be absorbed without the clay changing its volume, this water filling in the space between the grains. It may be termed pore water.

The presence of more water than is required to fill the spaces between the grains produces a swelling of the mass, and in this condition each grain is regarded as being surrounded by a film of water; but while the grains still mutually attract each other the attraction is less than in the dry clay, and the mass yields readily to pressure. An excess, however, separates the clay particles to such an extent that the clay softens and runs. A clay will, therefore, continue to swell as water is added to it, until the amount becomes too great to permit it to retain its shape.

The amount of air shrinkage is usually low in sandy clays, at times being under 1 per cent in coarsely sandy ones, while it is high in very plastic clays, or in some very fine-grained ones, reaching at times as much as 12 or 15 per cent. Five or six per cent is about the average seen in the manufacture of clay products.

All clays requiring a high percentage of water in mixing do not show a high air shrinkage. The air shrinkage of a clay will not only vary with the amount of water added, but also with the texture of the materials.

Sand or materials of a sandy nature counteract the shrinkage, and are frequently added for this purpose, but, since they also render the mixture more porous, they facilitate the drying as well, permitting the water to escape more readily, and often reducing the danger from cracking. If the sand added to dilute the shrinkage is refractory it also aids the clay in retaining its shape during burning.

Fire Shrinkage.—All clays shrink during some stage of the burning operation, even though they may expand slightly at certain temperatures. The fire shrinkage, like the air shrinkage, varies within wide limits, the amount depending partly on the quantity of volatile elements, such as combined water, organic matter, and carbon dioxide, and partly on the texture and fusibility.

Fire shrinkage may begin at a dull red heat, or about the point at which chemically combined water begins to pass off, and reaches its maximum when the clay vitrifies, but does not increase uniformly up to that point. The clay worker, however, always tries to get a low fire shrinkage, using a mixture of clays if necessary in order to prevent cracking and warping. After the expulsion of the volatile elements the clay is left in a porous condition, until the fire shrinkage recommences.

FUSIBILITY.

All clays fuse at one temperature or another, the temperature of fusion depending on (1) the amount of fluxes; (2) the size of grain of the refractory and non-refractory particles; (3) the homogeneity of the mass; (4) the condition of the fire, whether oxidizing or reducing; and (5) the form of chemical combination of the elements contained in the clay.

When clays undergo a fusion process they do not soften at once, but melt with comparative slowness. This is not surprising when we consider their heterogeneous composition, and may account for their slow softening, as one kind of mineral after another fuses. As soon as a softening of one or more of the mineral grains occurs, interreactions between the different ones begin, the number involved increasing until all constituents of the mass are involved. In most cases no reaction occurs between any of the grains until one melts, but it is not necessary to reach the fusion point of each before it can react with the others.

Incipient Vitrification.—In this stage the clay has softened sufficiently to make the grains stick together, and enough to prevent the recognition of any, except the larger ones. The particles have not, however, softened sufficiently to close up all pores of the mass.

Complete Vitrification.—A further heating of the clay, through a variable temperature interval ranging from about 27·7° C (500° F) to 111·1° C (200° F), or sometimes even more, produces an additional softening of the grains sufficient to close up all the pores and render the mass impervious. Clays burned to this condition of complete vitrification show a smooth fracture, with a slight lustre. The attainment of this condition also represents the point of maximum shrinkage.

Viscosity.—A still further variable rise in the temperature is accompanied by both swelling and softening of the clay, until it flows or gets viscous.

It is sometimes difficult to recognize precisely the exact attainment of these three conditions, for the clay may soften so slowly that the change from one to the other is gradual.

SEGER CONES.

These test pieces consist of a series of mixtures of clays with fluxes, so graded that they represent a series of fusion-points, each being a few degrees higher than the one next to it. They are so called because originally introduced by H. Seger, a German ceramist. The materials which he used in making them were such as would have a constant composition, and consisted of washed Zettlitz kaolin, Rörstrand feldspar, Norwegian quartz, Carrara marble, and pure ferric oxide. Cone 1 melts at the same temperature as an alloy composed of one part of platinum and nine parts of gold, or at 1150° C (2102° F). Cone 20 melts at the highest temperature obtained in a porcelain furnace, or at 1530° C (2786° F). The difference between any two successive numbers is 20° C (36° F), and the upper member of the series is cone 39. Cone 36 is composed of a very refractory clay slate, while cone 35 is composed of kaolin from Zettlitz, Bohemia. A lower series of numbers was produced by Cramer, of Berlin, who mixed boracic acid with the materials already mentioned. Hecht obtained still more fusible mixtures by adding both boracic acid and lead in proper proportions to the cones. The result is that there is now a series of 61 numbers, the fusion-point of the lowest being 590° C (1094° F) and that of the highest 1940° C (3470° F). As the temperature rises the cone begins to soften, and when its fusion-point is reached it begins to bend over until its tip touches the base. For practical purposes these cones are very successful, though their use has been somewhat unreasonably discouraged by some. They have been much used by foreign manufacturers of clay products, and their use in the United States and Canada is increasing.

The composition and fusing points of the different members of the series are given below:—

COMPOSITION AND FUSING-POINTS OF SEGER CONES.

No. of Cone.	Composition.	Fusing-point. Degrees F.	Fusing-point. Degrees C.
·022	{0·5 Na_2O, 0·5 PbO} {2·0 SiO_2, 1·0 B_2O_3}	1,094	590
·021	{0·5 Na_2O, 0·5 PbO} 0·1 Al_2O_3 {2·2 SiO_2, 1·0 B_2O_3}	1,148	620
·020	{0·5 Na_2O, 0·5 PbO} 0·2 Al_2O_3 {2·4 SiO_2, 1·0 B_2O_3}	1,202	650
·019	{0·5 Na_2O, 0·5 PbO} 0·3 Al_2O_3 {2·6 SiO_2, 1·0 B_2O_3}	1,256	680
·018	{0·5 Na_2O, 0·5 PbO} 0·4 Al_2O_3 {2·8 SiO_2, 1·0 B_2O_3}	1,310	710
·017	{0·5 Na_2O, 0·5 PbO} 0·5 Al_2O_3 {3·0 SiO_2, 1·0 B_2O_3}	1,364	740
·016	{0·5 Na_2O, 0·5 PbO} 0·55 Al_2O_3 {3·1 SiO_2, 1·0 B_2O_3}	1,418	770
·015	{0·5 Na_2O, 0·5 PbO} 0·6 Al_2O_3 {3·2 SiO_2, 1·0 B_2O_3}	1,472	800
·014	{0·5 Na_2O, 0·5 PbO} 0·65 Al_2O_3 {3·3 SiO_2, 1·0 B_2O_3}	1,526	830
·013	{0·5 Na_2O, 0·5 PbO} 0·7 Al_2O_3 {3·4 SiO_2, 1·0 B_2O_3}	1,580	860
·012	{0·5 Na_2O, 0·5 PbO} 0·75 Al_2O_3 {3·5 SiO_2, 1·0 B_2O_3}	1,634	890
·011	{0·5 Na_2O, 0·5 PbO} 0·8 Al_2O_3 {3·6 SiO_2, 1·0 B_2O_3}	1,688	920
·010	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·50 SiO_2, 0·50 B_2O_3}	1,742	950
·09	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·55 SiO_2, 0·45 B_2O_3}	1,778	970
·08	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·60 SiO_2, 0·40 B_2O_3}	1,814	990
·07	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·65 SiO_2, 0·35 B_2O_3}	1,850	1,010
·06	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·70 SiO_2, 0·30 B_2O_3}	1,886	1,030
·05	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·75 SiO_2, 0·25 B_2O_3}	1,922	1,050
·04	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·80 SiO_2, 0·20 B_2O_3}	1,958	1,070
·03	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·85 SiO_2, 0·15 B_2O_3}	1,994	1,090
·02	{0·3 K_2O, 0·7 CaO} {0·2 Fe_2O_3, 0·3 Al_2O_3} {3·90 SiO_2, 0·10 B_2O_3}	2,030	1,110

COMPOSITION AND FUSING-POINTS OF SEGER CONES.

No. of Cone.	Composition.	Fusing-point. Degrees F.	Fusing-point. Degrees C.
·01	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}\left\{\begin{matrix}0{\cdot}2\ Fe_2O_3\\0{\cdot}3\ Al_2O_3\end{matrix}\right\}\left\{\begin{matrix}3{\cdot}95\ SiO_2\\0{\cdot}05\ B_2O_3\end{matrix}\right\}$	2,066	1,130
1	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}\left\{\begin{matrix}0{\cdot}2\ Fe_2O_3\\0{\cdot}3\ Al_2O_3\end{matrix}\right\}\left\{4\ SiO_2\right\}$	2,102	1,150
2	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}\left\{\begin{matrix}0{\cdot}1\ Fe_2O_3\\0{\cdot}4\ Al_2O_3\end{matrix}\right\}\left\{4\ SiO_2\right\}$	2,138	1,170
3	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}\left\{\begin{matrix}0{\cdot}05\ Fe_2O_3\\0{\cdot}45\ Al_2O_3\end{matrix}\right\}\left\{4\ SiO_2\right\}$	2,174	1,190
4	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}0{\cdot}5\ Al_2O_3\ 4\ SiO_2$	2,210	1,210
5	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}0{\cdot}5\ Al_2O_3\ 5\ SiO_2$	2,246	1,230
6	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}0{\cdot}6\ Al_2O_3\ 6\ SiO_2$	2,282	1,250
7	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}0{\cdot}7\ Al_2O_3\ 7\ SiO_2$	2,318	1,270
8	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}0{\cdot}8\ Al_2O_3\ 8\ SiO_2$	2,354	1,290
9	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}0{\cdot}9\ Al_2O_3\ 9\ SiO_2$	2,390	1,310
10	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}1{\cdot}0\ Al_2O_3\ 10\ SiO_2$	2,426	1,330
11	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}1{\cdot}2\ Al_2O_3\ 12\ SiO_2$	2,462	1,350
12	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}1{\cdot}4\ Al_2O_3\ 14\ SiO_2$	2,498	1,370
13	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}1{\cdot}6\ Al_2O_3\ 16\ SiO_2$	2,534	1,390
14	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}1{\cdot}8\ Al_2O_3\ 18\ SiO_2$	2,570	1,410
15	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}2{\cdot}1\ Al_2O_3\ 21\ SiO_2$	2,606	1,430
16	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}2{\cdot}4\ Al_2O_3\ 24\ SiO_2$	2,642	1,450
17	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}2{\cdot}7\ Al_2O_3\ 27\ SiO_2$	2,678	1,470
18	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}3{\cdot}1\ Al_2O_3\ 31\ SiO_2$	2,714	1,490
19	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}3{\cdot}5\ Al_2O_3\ 35\ SiO_2$	2,750	1,510
20	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}3{\cdot}9\ Al_2O_3\ 39\ SiO_2$	2,786	1,530
21	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}4{\cdot}4\ Al_2O_3\ 44\ SiO_2$	2,822	1,550
22	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}4{\cdot}9\ Al_2O_3\ 49\ SiO_2$	2,858	1,570
23	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}5{\cdot}4\ Al_2O_3\ 54\ SiO_2$	2,894	1,590
24	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}6{\cdot}0\ Al_2O_3\ 60\ SiO_2$	2,930	1,610
25	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}6{\cdot}6\ Al_2O_3\ 66\ SiO_2$	2,966	1,630
26	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}7{\cdot}2\ Al_2O_3\ 72\ SiO_2$	3,002	1,650
27	$\left\{\begin{matrix}0{\cdot}3\ K_2O\\0{\cdot}7\ CaO\end{matrix}\right\}20\ Al_2O_3\ 200\ SiO_2$	3,038	1,670

COMPOSITION AND FUSING-POINTS OF SEGER CONES.

No. of Cone.	Composition.	Fusing-point.	
		Degrees F.	Degrees C.
28	Al_2O_3 10 SiO_2	3,074	1,690
29	Al_2O_3 8 SiO_2	3,110	1,710
30	Al_2O_3 6 SiO_2	3,146	1,730
31	Al_2O_3 5 SiO_2	3,182	1,750
32	Al_2O_3 4 SiO_2	3,218	1,770
33	Al_2O_3 3 SiO_2	3,254	1,790
34	Al_2O_3 2·5 SiO_2	3,290	1,810
35	Al_2O_3 2 SiO_2	3,326	1,830
36	Al_2O_3 1·5 SiO_2	3,362	1,850
37		3,398	1,880
38		3,434	1,910
39		3,470	1,940

In actual use they are placed in the kiln at a point where they can be watched through a peep-hole, but at the same time will not receive the direct touch of the flame from the fuel. It is always well to put two or more cones of different numbers in the kiln, so that warning can be had, not only of the end point of firing, but also of the rapidity with which the temperature is rising.

In determining the proper cone to use in burning any kind of ware, several cones are put in the kiln, as, for example, numbers ·08, 1, and 5. If ·08 and 1 are bent over in burning, and 5 is not affected, the temperature of the kiln is between 1 and 5. The next time numbers 2, 3, and 4 are put in, and 2 and 3 may be fused, but 4 remains unaffected, indicating that the temperature reached the fusing-point of 3.

While the temperature of fusion of each cone is given in the preceding table, it must not be understood that these cones are for measuring temperature, but rather for measuring pyrochemical effects.

The cones used in the different branches of the clay-working industry in the United States and Canada are approximately as follows:—

Common brick	012–01
Hard burned, common brick	1–2
Buff face brick	5–9 or even higher.
Hollow blocks and fireproofing	08–1
Terra-cotta	02–7 or 8
Conduits	7–8

8-9
White earthenware.................................5-14
Firebricks.................................11-13
Porcelain.................................010-05
Red earthenware.................................6-8
Stoneware.................................10-12
Electrical porcelain.................................3-7
Sewer pipe.................................

APPENDI

Laboratory Number.	Field Number.	Locality.	Per cent Water Required.	Air Shrinkage.	Fire Shrinkage.	
1505	15	Shale, near Victoria Mines P. O., Sydney	......	5·0	0	F
1511	41 (a)	Drift clay and shale mixture, New Glasgow	15·4	5·0	0	
1518 (a)	......	Mixture, Coxheath felsite and Hussey clay	17·0	5·6	−0·6	
1523	22	Yellow clay, Mira River Brick Works	24·2	3·1	−0·6	R
1530	11	Shale, west of Black point, under Lloyd Seam, C.B	......	4·0	3·4	B
1531	8	Lower 3 feet of shale, Cranberry head, C.B	......	......	5·3	
1532	7	Layer, 3 feet thick, 6 feet from top, shale at Cranberry head	......	5·1	0·5	R
1533	5	Upper part of shale bed, Cranberry head, C.B	......	5·0	0·5	B
1534	29	Shale, east side of Oxford point, C.B.	17·6	4·0	1·0	
1535	31	Shale with Crawley seam, Big Bras d'Or, C.B	......	4·6	0·0	
1536	32	" " "	......	6·6	1·4	
1537	33	Shale with coal, near Black Rock point, Big Bras d'Or	......	4·3	0·0	
1538	34	" " "	......	4·7	0·0	
1539	17	Shale on shore of Sydney harbour, 500 feet north of Victoria Mines P O	......	3·0	0·0	B
1540	50	Black shale, near ford on McLellan brook, New Glasgow	......	3·7	0·7	.
1542	40	Shale, Bear head, south of Hawkesbury	13·2	1·3	0·0	L
1544	38	Shale, near Marine Hospital, Point Edward, Sydney	18·6	3·9	0·3	P
1545	36	Shale, from Fan shaft, No. 4 Colliery, Sydney Mines	22·0	4·5	−0·5	B
1546	20	Shale, about 1½ miles east of Lower Barachois, C.B	17·6	3·3	0·0	L
1547	19	Red shale, about 1½ miles east of Lower Barachois, C.B	......	4·1	0·3	R
1548	18	Shale from first cove, east of Lower Barachois, C.B	19·8	5·0	......	L
1549	39	Shale ¼ mile south of Indian cove, Sydney harbour	17·6	4·3	0·7	
1550	46	Shale, East River, opposite Allan shaft, New Glasgow	16·8	3·3	0·0	R
1551	51	Shale on brook between New Glasgow and Woodburn	22·0	6·0	0·6	L
1552	16	Shale, near Victoria Mines P.O	13·0	4·2	5·9	R
1568	86	Blue clay from marsh, Albert Mines, N.B	......	5·0	11·6	
1570	70	Shale above sandstone quarry, north of Port Hood	22·0	6·0	−0·4	P
1571	72	Green shale, south of Port Hood	33·0	6·0	0·3	B
1572	56	Fireclay, Shubenacadie	24·2	7·0	0·0	W
1574	80	Shale near sandstone quarry, north of Dorchester, N.B	17·6	5·5	−0·5	R
1575	71	Shale on shore, Port Hood	19·4	5·0	0·4	P
1576	81	Shale, near sandstone quarry, north of Dorchester	16·8	5·0	0·5	R
1577	77	Shale along shore, south of Joggins	18·8	4·4	0·0	
1578	73	Sub-carboniferous shale, south of Port Hood	22·0	3·6	−0·3	
1579	57	Fireclay, Shubenacadie	......	5·8	−0·6	W
1580	57 (a)	Red clay, Diogenes brook, C.B.	19·0	6·6	−0·9	R
1581	57 (b)	White clay "	22·0	6·3	0·1	.
1583	57 (d)	Blue clay "	20·0	7·0	−0·2	.
1584	57 (e)	Red shale, Sackville, N. B	22·0	6·0	−0·6	.
1585	57 (f)	Tidal mud, Shubenacadie	......	1·0	......	
1586	57 (g)	Shale, Port Hood	29·0	8·1	0·7	R
1587	62	Shale on shore, between Inverness and Big river	22·0	5·1	−0·8	B
1588	63	" " "	19·4	4·4	0	R
1589	67	Underclay, 13 ft. seam, Kennedy brook, Inverness	13·2	4·3	−0·4	P
1590	67 (a)	Brick clay, Baddeck, C.B.	27·2	6·3	1·2	
1591	67 (b)	Red shale near Harcourt	15·4	5·5	−0·2	R
1593	91	Underclay, King mine, Minto, N.B	13·2	3·0	−0·8	B
1594	92	Shale over coal, Barnes mine, Minto.	14·4	4·6	0·0	L
1595	93	Underclay "	24·2	6·6	0·15	P
1596	88	Shale from Chipman, N.B., at R. R. station	16·6	5·2	0·2	D
1597	......	White surface clay, near Marshalltown	33·0	6·5	0·0	W
1598	......	Shale from Bloomfield farm, near Shubenacadie	30·4	8·6	0·3	P
1605	76	Brick clay, Annapolis	18·6	7·2	1·3	R
1606	75	Brick clay, Middleton	21·2	7·0	0·3	L
1607	......	Silurian shale, Arisaig	......	1·1	−0·8	R
1609	......	Shale from Baltimore, N.B	22·0	4·5	−1·6	P

NDIX I.

WET MOULDED.

Cone 010.			Cone 03.			Cone 1.		
Fire Shrinkage.	Colour.	Per cent Absorption.	Fire Shrinkage.	Colour.	Per cent Absorption.	Fire Shrinkage.	Colour.	Per cent Absorption.
0	Red buff	11·65	1·0	Brown	5·27			
0	"	11·66	7·0	Bright red	5·70			
−0·6								
−0·6	Red	20·62	1·5	Dark red	18·18	2·0	Dark red	14·06
3·4	Buff	18·56				6.0	Reddish brown	2·42
5·3	"	13·62				2·0	"	6·08
0·5	Red	19·96				4·0	"	4·72
0·5	Buff	14·42				5·0	Brown	3·08
1·0	"	16·97				6·3	Reddish brown	1·22
0·0	"	16·64				7·6	"	2·09
1·4	"	15·43				5·3	Red	4·27
0·0	"	13·76						
0·0	"	15·79						
0·0	Brown	10·13						
0·7		19·02	1·0	Red	13·88	1·6	Red	14·24
0·0	Dark red	13·37		Dark red	9·13			
0·3	Pink	10·78						
−0·5	Buff	12·71	1·0	Buff	7·77	4·0	Buff	5·17
0·0	Dark red	14·26						
0·3	Red	13·18	1·6	Reddish brown	4·52			
	Light red	13·11				5·0	Red	7·9
0·7	"	13·42	5·0	Dark red	5·84			
0·0	Red	18·37	5·6	"	9·36	3·6	Dark red	8·99
0·6	Light red	15·65				7·0	"	2·76
5·9	Red	6·91						
11·6	Cracks and warps in the burning.							
−0·4	Pink	14·0	6·3	Red	9·24			
0·3	Buff	20·18	6·3	Pink	12·62			
0·0	White	20·19				5·4	White	10·17
−0·5	Red	13·15	5·6	Dark red	3·78			
0·4	Pink	13·69	5·0	"	4·11			
0·5	Red	13·90	6·0	"	3·62			
0·0	"	13·50	6·3	"	1·32			
−0·3	"	15·70	4·3	Reddish brown	8·20			
−0·6	White	14·23	2·0	White	11·00	2·0		10·74
−0·9	Red	13·66	0·0	Pink	12·03			
0·1		13·72	1·0		12·41			
−0·2		11·97	4·0		6·73			
−0·6		14·74	7·0		1·98			
0·7	Reddish buff	19·00	8·0	Reddish brown	0·21			
−0·8	Buff	18·06	7·7	Red	5·42			
0	Reddish buff	16·01	3·0	"	8·88			
−0·4	Pink	16·72	0·0	Pink	16·01			
1·2	"	16·02	8·6	Reddish brown	22·97			
−0·2	Red	13·51	0·3	Dark red	9·24			
−0·8	Buff	10·11	1·6	Red	6·85			
0·0	Light red	11·60	4·0	Light red	5·29	4·7	Dark red	1·30
0·15	Pink	13·27	4·0	Red	7·38	5·0	"	0·75
0·2	Dark buff	12·52	5·7	"	4·14			
0·0	White	25·94	1·6	White	21·22	5·0	Cream	12·6[illegible]
0·3	Pink	21·83	1·6	Red	17·10			
1·3	Red	13·41	5·3	"	5·85			
0·3	Light red	21·36	2·0	"	13·31			
−0·8	Red	15·41						
−1·6	Pink	15·52		Swelled up				

Laboratory Number.	Field Number.	Locality.	Per cent water required.	Average tensile strength, lbs. per square inch.	Per cent through 200 Mesh.	Air Shrinkage.	Cone 010. Fire Shrinkage.	Cone 010. Colour.	Cone 010. Per cent Absorption.	Cone 05. Fire Shrinkage.	Cone 05. Colour.	Cone 05. Per cent Absorption.	Co Fire Shrinkage.	Col
1501	53	Mottled shaly clay, northeast of Woodburn Station	19·8	157	64·6	6·0	0·3	Red	12·75	3·0	Red	10·33	3·3	Dark red
1502	27	Underclay, North Atlantic Coal Co., Port Morien	15·4	64	33·4	5·6	0·4	"	17·25	3·3	"	12·32	5·0	Red
1503	1	Brick clay, Elmsdale	30·5	143	90·6	6·3	4·0	"	13·60	9·6	Reddish brown	2·22	4·0	Dark red
1504	41	Shale, Standard Drain Pipe Co., New Glasgow	17·6	107	31·2	5·5	−0·3	Buff	14·20	3·6	"	6·81	4·0	Brown
1506	47	Shale, Intercolonial Coal Co., Westville	13·0	60	26·4	3·6	0·0	"	11·03	2·0	Buff	9·19	2·3	Buff
1507	52	Shale, one mile west of Woodburn	18·5	190	35·6	7·6	−0·3	Pink	12·60	1·3	"	9·93	1·3	"
1508	9	Shale, run of bank, Cranberry head, C.B	22·0	85	33·6	6·0	1·7	"	15·01	4·3	Dark red	8·30	4·6	Dark red
1509	35	Shale under sandstone, Ashby pit, Sydney	22·0	148	46·0	9·2	1·2	Buff	11·24	4·3	Dark buff	6·75	5·0	Light buff
1510	30	Shale near Alder Point P.O., C.B	15·4	68	25·0	5·9	0·2	Light red	12·49	2·0	Dark red	7·90	2·3	Red
1512	53 (a)	Brick clay, Eden siding	25·0	230	88	7·7	1·5	Red	16·24	4·3	"	9·85	5·0	Dark red
1513	28	Shale under middle coal, west side of Black Point, C.B	23·8	75		5·7	1·6		......	3·0	Light red	13·20	4·6	Light red
1513 (a)	.....	The same, ground coarse	18·5	51	25·2	5·2	1·0	Pink	14·86	4·0	"	12·62	4·0	"
1514	25	Shale east of entrance to Glace Bay harbour	15·0	50	...	5·7	0·3	Red	13·12	1·6	Dark red	10·48	3·3	......
1514 (a)	...	Same, ground finer	17·6	67	....	5·0	−1·0	"	14·66	1·5	"	10·48	3·3	Red
1515	24	Shale east of No. 2 Colliery, Glace Bay	13·2	58	30·6	6·1	1·0	Light red	12·72	3·6	"	6·74	4·6	"
1516	45	Shale, Coal brook, south of Allen shaft, New Glasgow	18·6	146	33·2	5·0	0·0	"	15·11	1·6	Reddish brown	11·51	2·3	Reddish br
1517	42	Brooks lower shale, New Glasgow	18·0	98	58·6	5·1	0·0	Cream	11·42	2·3	Buff	8·43	3·6	Buff
1519	10	Red shale, Cranberry head	16·8	71	20·8	5·2	0·4	Red	14·00	5·3	Dark red	5·71	7·0	Dark red
1520	3	Pottery clay, south of Elmsdale	30·8	226	70·0	8·3	1·3	"	11·81	7·6	Reddish brown	0·20	8·3	Reddish br
1521	13	Yellow clay, No. 3 Colliery, Nova Scotia Coal Co	20·8	122	45·6	6·7	1·3	"	11·49	5·6	Dark red	3·87	7·3	Dark red
1522	48	Fireclay, Shubenacadie	22·0	110	74·0	6·3	−0·1	White	14·90	0·6	White	13·90	1·6	White
1524	21	Blue clay, Mira River Brick Works, C.B	24·0	60	99·0	7·1	−0·8	Reddish brown	19·49	2·0	Red	15·32	4·0	Red
1525	54	Glacial clay, McKinnon harbour	20·8	222	64·6	7·6	0·4	Red	14·27	2·6	Dark red	9·92	3·0	Dark red
1526	12	Underclay, Toronto mine, C.B	27·2	129	32·2	7·7	0·2	Buff	16·10	5·0	Buff	6·52	6·0	Buff
1527	23	Brick mixture, Mira River Brick Works, C.B	21·2	118	67·6	6·7	0·3	Red	11·45	4·3	Dark red	6·61	5·0	Dark brown
1528	44	Underclay, of Cage seam, Stellarton	17·0	69	26·4	5·0	0·8	Dark buff	15·14	3·3	Reddish brown	12·20	5·6	"
1529	4	Lower red clay at Pottery, south of Elmsdale	31·6	194	89·2	9·2	2·4	Red	14·69	8·0	Dark red	0·42	9·3	Reddish brown
1543	2	Brick mixture, Elmsdale	23·8	140	70·6	7·3	1·6	"	8·54	6·0	Reddish brown	4·23	7·0	"
1553	64	Top clay, Hussey drift, Inverness	30·8	206	58·4	8·5	0·3	Buff	15·74	4·3	Buff	9·79	......	Dark buff
1554	65	Shale, south of McIsaac pond, Inverness	21·2	145	61·6	5·7	0·8	"	12·13	2·6	"	9·61	6·6	Reddish brown
1555	83	Underclay, Beersville, N.B	20·2	103	45·4	7·0	−2·3	"	13·64	2·0	Dark buff	8·67	0·0	"
1556	82	Clay over coal, Beersville, N.B	16·4	87	27·2	4·5	0·0	"	10·23	2·0	Red	13·19	6·0	Dark red
1557	55	Brick clay, Baddeck, C.B	24·2	56	94·6	7·0	0·5	Pink	15·06	4·3	Light red	9·81	5·3	Reddish brown
1558	73	Shale, north of Judique harbour	29·4	65	..	5·8	0·2	"	20·52	7·6	Red	4·94	9·6	"
1559	68	Clay over 13 ft. seam, McLellan brook, Inverness	28·6	164	50·6	7·8	0·8	Buff	16·81	4·0	Buff	8·81	7·0	Dark buff
1560	84	Shale, south branch Frederick brook, Albert Mines, N.B	21·2	137	42·4	6·2	0·3	Red	13·00	0·6	Red	14·55	1·0	Red
1561	60	Mottled clay, Murphy brook, Mid. Musquodoboit	30·8	68	91·6	6·5	0·1	Salmon pink	21·68	2·6	Salmon pink	18·29	6·0	Pale pink
1562	87	Brick clay, Fredericton, N.B	33·4	109	94·0	7·8	−0·2	Red	22·08	3·6	Dark red	1·69	10·3	Dark brown
1563	78	Shale from parting in seam, Joggins	17·6	58	......	5·1	0·6	"	10·00	3·6	Red	6·72	3·0	Red
1564	74	Brick clay, Avonport	25·6	145	96·0	7·2	2·2	"	11·36	5·0	"	6·43	6·6	Reddish brown
1565	79	Shale, Pugwash	22·0	75	67·0	6·0	0·1	"	14·53	3·6	Dark red	8·31	7·3	"
1566	59	Grey clay, Murphy brook, Middle Musquodoboit	26·4	81	99·0	6·8	0·4	White	19·30	2·3	White	16·71	6·0	White
1567	85	Red shale, Weldon creek, Albert Mines, N.B	19·8	74	31·6	5·6	1·1	Red	13·14	1·3	Dark red	11·22	1·0	Dark red
1601	94	Underclay, Can. Coal Co., Salmon bay, N.B	15·0	25	...	4·8	0·0	Buff	10·20	2·6	Red	4·60	2·3	"
1602	95	Shale over coal, Can. Coal Co., Salmon bay, N.B	16·0	62	..	4·7	0·0	Dark buff	12·60	2·0	Light red	9·19	2·3	Red
1603	.....	Weathered shale, Flower Cove, N.B	26·4	201	48·6	8·6	0·3	Cream pink	15·91	1·3	Cream pink	14·6	1·6	Cream
1604	.....	Brick mixture, St. John, N.B	22·8	69	77·6	4·1	1·2	Red	15·44	1·6	Red	13·09	3·0	Dark red
1608	.....	Shale, Flower Cove, N.B	20·8	252	45·0	8·2	0·3	White	12·37	1·6	Cream	11·97	2·0	Cream
1610	.....	Overclay, Evans mine, Minto, N.B	.....	...		3·5	0	Pale red	11·5	4·3	Red	3·7	..	......
1611	.....	Underclay " "	.....	.....		3·8	0·3	Buff	15·0	0·6	Buff	13·6	......	......

PENDIX II

Wet Moulded.															Dry Press.		
Cone 03.			Cone 1.			Cone 3.			Cone 5.			Cone 9.					
Shrinkage.	Colour.	Per cent Absorption.	Fire Shrinkage.	Colour.	Per cent Absorption.	Fire Shrinkage.	Colour.	Per cent Absorption.	Fire Shrinkage.	Colour.	Per cent Absorption.	Fire Shrinkage.	Colour.	Per cent Absorption.	Cone.	Colour.	Per cent Absorption.
3	Dark red	8·14	4·3	Reddish brown	1·77	5·0	Reddish brown	1·54							03	Red	9·80
9	Red	9·88	6·0	Brown	3·52										03	"	19·00
0	Dark red	9·00													03	Brown	0·63
0	Brown	6·9	6·0		2·10												
3	Buff	8·08	4·0	Buff	4·80	4·0	Buff	5·04							03	Buff	9·25
3	"	9·73	2·3	"	4·14	2·7	Yellowish grey	2·42	3·3	Yellowish grey	2·15	2·3	Brown	1·88	03	Reddish brown	8·21
	Dark red	6·46	5·6	Dark brown	1·35	5·7	Dark brown	1·45							03	"	13·20
	Light buff	6·40	5·0	Light buff	3·83	0·3	Buff	3·43	2·3	Buff	4·16				03	Buff	12·08
	Red	6·85	2·0	Dark brown	1·89	1·3	Dark brown	1·30							03	Reddish brown	11·80
	Dark red	7·62													03	Dark red	9·16
	Light red	10·61	9·3	Dark brown	1·08												
	"	9·70	7·0	"	1·39										03	Red	13·52
			5·3														
	Red	2·27	5·3	Dark brown	1·15										03	Red	9·00
	"	5·53															
	Reddish brown	9·00													03	Reddish brown	14·20
	Buff	7·57	6·0	Buff	2·04	5·0	Dark brown	0·90	5·0	Grey	1·20	0·0	Brown	0·80	03	Buff	12·10
	Dark red	2·24													03	Dark red	6·02
	Reddish brown	0·03													03	"	4·52
	Dark red	3·62													03	"	6·29
	White	12·05	2·0	Cream	9·95	3·0	Buff	9·10	3·0	Cream	9·00	4·0	Buff	4·41	1	Cream	15·75
	Red	9·37	6·6												03	Red	15·06
	Dark red	10·19	3·6	Dark brown	0·94										03	Reddish brown	15·60
	Buff	1·87	7·3	Yellowish brown	0·27										03	Yellowish brown	12·59
	Dark brown	1·43	1·0	Dark brown	1·59										03	Dark brown	8·78
	"	4·37	5·7	"	4·93	4·0	Dark brown	2·26							03	Mottled brown	12·20
	Reddish brown	0·00															
	"	1·14													03	Brown	10·01
	Dark buff	2·25	6·6	Buff	0·00	7·3	Brown	0·00	10·0	Drab	0·00	5·0	Drab	0·00	03	Buff	10·90
	Reddish brown	3·18	6·6	Reddish brown	1·80	5·0	"	0·00							03	Pink	11·68
	"	7·12													03	Mottled red	12·60
	Dark red	1·62													03	Reddish brown	7·45
	Reddish brown	4·30	7·6	Dark brown	0·07										03	"	
	"	1·51	12·6	Reddish brown	0·11												
	Dark buff	0·70	7·0	Drab	0·00	7·0	Brown	0·00	6·3	Drab	0·00				1	Dark buff	6·4
	ed	13·37	5·3	Brown	7·32												
	ale pink	12·96	6·3	Red	7·00	8·3	Pink	5·41	7·3	Reddish brown	3·66	9·0	Red brown	0·29	1	Mottled pink	
	ark brown	0·02													03	Dark red	0·91
	ed	5·00															
	eddish brown	2·96													03	Reddish brown	6·43
	"	2·95													03	Dark red	8·16
	hite	15·92	6·0	White	7·41	7·0	Cream	7·71	7·3	Cream	4·89	8·0	Cream	4·34	1	Cream	14·78
	ark red	13·15															
	"	2·63	2·3	Dark brown	0·75												
	ed	7·78	3·3		3·19	3·6	Red brown	2·4							03	Reddish brown	7·69
	eam	12·69	5·0	Cream	8·87				7·7	Grey	0·26				03	Buff	13·76
	ark red	12·40													03	Light red	15·34
	eam	11·06	2·6	Cream	8·09				4·33	Speckled buff	5·00				03	Buff	14·41
			4·3	Red brown	1·4	4·3	Red brown	1·4									
			1·0	Buff	10·7	1·6	Buff	10·0	2·0	Buff	8·0	2·33	Buff	9·4			

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CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

HON. W. TEMPLEMAN, MINISTER; A. P. LOW, DEPUTY MINISTER; R. W. BROCK, DIRECTOR.

SELECTED LIST OF REPORTS AND MAPS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

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THE GEOLOGICAL SURVEY.

Report of Mines Section:—

No. 245.	Report of Mines Section,	1886.	No. 662.	Report of Mines Section,	1897.
272	" "	1887.	698	" "	1898.
*300	" "	1888.	718	" "	1899.
301	" "	1889.	744	" "	1900.
334	" "	1890.	800	" "	1901.
335	" "	1891.	835	" "	1902.
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602	" "	1895.	971	" "	1905.
625	" "	1896.			

Mineral Production of Canada:—

No. *414.	Year 1886.	No. *422.	Year 1893.	No. 719.	Year 1900.
*415	" 1887.	*555	" 1894	719a	" 1901.
*416	" 1888.	*577	" 1895	813	" 1902.
*417	" 1889.	*612	" 1896.	861	" 1903.
*418	" 1890.	*623	" 1886-96	896	" 1904.
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*420	" 1886-91	*671	" 1898.	981	" 1906.
*421	" 1892.	*686	" 1899.		

Mineral Resources Bulletin:—

No. *818.	Platinum.	No. 860.	Zinc.	No. 881.	Phosphate.
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*854.	Asbestos.	872.	Molybdenum and Tungsten.	913.	Mineral Pigments.
857.	Infusorial Earth.	*877.	Graphite.	953.	Barytes.
858.	Manganese.	880.	Peat.	984.	Mineral Pigments (French).
859	Salt.				

Report of the Section of Chemistry and Mineralogy:—

No. *102.	Year 1874-5.	No. *169.	Year 1882-3-4.	No. 580.	Year 1894.
*110	" 1875-6.	222.	" 1885.	616	" 1895.
*119	" 1876-7.	246	" 1886.	651	" 1896.
*126	" 1877-8.	273	" 1887-8.	695	" 1898.
*138	" 1878-9.	299	" 1888-8.	724	" 1899.
*148	" 1879-80.	333	" 1890-1.	821	" 1900.
*156	" 1880-1-2.	359	" 1892-3.	*958	" 1906.

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745. Altitudes of Canada, by J. White. 1899.
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1073. Catalogue of Publications: Reports and Maps (1843-1909).
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