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Clay and Shale Deposits of the Western Provinces Part III.

BY

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Clay and Shale Deposits of the Western Provinces

Part III

INTRODUCTORY.

Two years ago, the writer and Mr. J. Keele made a preliminary report on the clay and shale deposits of the western provinces, which was published as Memoir 24 of the Geological Survey. This report embodied the results of field work done by the authors during the field season of 1910, and the laboratory tests made the following winter on the samples collected in the field. The work covered in a preliminary way the country from Winnipeg to the Pacific coast and from the International Boundary to the latitude of Edmonton on the Great Plains, but not north of the Canadian Pacific railway in the mountains.

The field season of 1911 was spent in the same region by the two authors of the first report, in covering ground not visited the previous summer, and the results of this, which are now in press, will appear as Memoir 25 of the Geological Survey.

The next field season, viz., that of 1912, was occupied by the present writer in further studies in the same general area, the districts especially visited being: (1) Scattered localities in the Great Plains. (2) The route from Edmonton westward through the Yellow Head pass. (3) The Columbia valley from Golden to Lake Windermere, and thence down the Kootenay valley, to Fort Steele. (4) The Columbia valley from Revelstoke northward, to Downing river. (5) Scattered points in southern British Columbia. (6) The Fraser River valley between New Westminster and Silverdale. (7) Points in the Nanaimo region not hitherto visited. (8) The Prince Rupert district.

As was the custom on former trips, a number of samples for testing were collected in the field and the results of these tests are embodied in the present report.

SUMMARY OF RESULTS

Three seasons in the field have given a pretty clear idea regarding the clay resources of the western provinces, and of the several geological formations found in them, so that it will not be out of place at this point to give in summarized form the results of the several seasons field work, following the previous plan of grouping the occurrences first geographically, and then geologically.

GREAT PLAINS REGION

In this region between Winnipeg and the Rocky mountains, we have surface clays and shale formations. The former are the most widely used but the latter are the more valuable commercially.

Surface Clays.

Those surface clays used for brick-making purposes in the Great Plains region include: (1) Lake clays; (2) river-terrace or flood-plain deposits; and (3) delta deposits.

The lake clays are irregularly distributed, of variable character, and in some cases resemble some of the representatives of the other types in their physical properties. The dark grey clay underlying the brick clay in the Red River valley is of this type, and is avoided by the brick makers around Winnipeg as it cracks in burning.

The more sandy lake clays, however, such as those around Red Deer and Prince Albert, are used with satisfaction.

The flood-plain deposits are employed around Winnipeg and Edmonton.

In general the surface clays are silty or sandy, and often calcareous to such a degree that they give a cream-coloured product. Where not too sandy and lean they work well in a stiff-mud machine and can be utilized not only for common brick, but also for pressed brick, drain tile, and partition tile; but common brick is the chief product. Some of them have to be carefully dried to prevent cracking.

Winnipeg, Portage la Prairie, Saskatoon, and Edmonton are important producing localities.

In many districts these surface clays are the only available materials for brickmaking, and have to be used; in others they are sometimes chosen when better materials are at hand, simply because they work a little easier.

Shales.

The shale formations that are available for clay working include the Niobrara, Pierre, Belly River, Edmonton, Laramie, and Miocene.

The Niobrara shale is found in both Manitoba and Saskatchewan. In southern Manitoba, near Leary, the shale is very plastic, and somewhat carbonaceous, but it has been used successfully for dry-press brick. To the northward along the eastern face of the Porcupine hills the Niobrara is found in quantities, but is often too carbonaceous to be used alone, although it could probably be mixed with other shales.

In Saskatchewan, along Lost lake north of Regina there are also extensive exposures of the Niobrara which could be used for pressed brick, and tests of the shale from this region are given in Memoir 25 now in press.

Tests made in the laboratory also developed the fact that a mixture of Niobrara and Pierre shale can be employed to make sewerpipe.

The Pierre formation, which is composed almost wholly of shales, occupies the summits of all the higher land in the western part of the Province of Manitoba.

The upper portion of the Pierre contains a considerable thickness of hard, light-grey, fine-grained shale, the lower portion being made up of softer dark grey shale, which contains crystals of selenite, and nodules of clay iron stone. It is the former that is of more value to the clay worker.

The Pierre shales are found outcropping at a number of localities in the Province of Manitoba, but about the only point where an attempt has been made to utilize them is at LaRiviere, Manitoba, where they have been worked for pressed brick.

In order to get a good product from the Pierre shale, it should be finely ground and if possible mixed with a little plastic clay, as the shale alone does not develop very much plasticity nor burn to a dense body. With care it can be used in pressed-brick manufacture. The material is not a fireclay, as often thought to be, although it sometimes shows a fusing point of cone 10 or 12.

The Belly River formation underlies a large area of the plains (See Geological Map, Memoir 24), but outcrops are scarce owing to the heavy mantle of Pleistocene material, so that it is only well exposed as a rule in the cut banks of the larger rivers like the Belly and South Saskatchewan. But even there the sections are sometimes not continuous owing to the irregular upper surface of the formation.

There is no doubt but that this is an important shale formation, and one which contains strong possibilities. The characters of the shales may be summed up as follows: (1) usually red burning; (2) often very plastic; (3) occurrence somewhat lense-like, but lenses sometimes of considerable size; (4) fusion point not as a rule above cone 5 or 6; (5) many work smoothly through a die; (6) they usually have to be carefully dried to prevent cracking.

These shales form an important source of supply for making common brick, pressed brick, and fireproofing. More recently certain ones have been used for common earthenware.

At present they are worked only in the region around Medicine Hat, but they are accessible at other points, and the two preceding reports as well as the present one, contain tests of these shales from Bow Island, Taber, Lethbridge and vicinity, Milk Creek, near Pincher, etc.

The Laramie formation, proper, underlies a small triangular area in southern Manitoba in the Turtle Mountain region.

Farther west a second but much larger triangular area is found in southern Saskatchewan. The base of this triangle forms the southern boundary of this Province as far west as the Wood Mountain district, which is included in it.

From the apex of the triangle a narrow belt extends northwestward to a little beyond the main line of the Canadian

Pacific railway west of Moosejaw. This area includes the Souris coal field,[1] and the Dirt hills.

The Laramie formation has been found to contain two very contrasted types of clay deposits.

In the Souris coal field we have a number of shale deposits associated with the coal seams. These shales burn to a red or sometimes buff colour,[2] and are interbedded with coals and sandstones. Practically no attempt appears to have been made to utilize them except at Estevan.

The second type of clay is that found in the Dirt hills south of Moosejaw. Here we have deposits of white and grey clays of truly refractory character, and associated with them are clay shales of lower refractoriness.

By using proper mixtures of the different beds these materials can be used for making firebrick, pressed brick, sewerpipe, and stoneware. The deposits represent one of the greatest clay assets of the Great Plains area, and with the construction of the Canadian Northern, south from Moosejaw, and the Lethbridge-Moosejaw branch of the Canadian Pacific railway, the clays of this area become easily accessible.

Next in importance to the Laramie formation is the Edmonton formation. This underlies a belt of varying width extending from the centre of the Province of Alberta, and also extending westward from Edmonton towards the mountains.

In Alberta it is divided into two parts: (1) A coal-bearing member known as the Edmonton and likely to be the more productive of shales, and (2) a heavy sandstone formation known as the Paskapoo.

The first forms a trough, which is filled along its centre by the latter. This trough widens to the north, and also flattens, exposing a larger area of the Edmonton series than in the southern part.

The shales are found with the coal seams around Edmonton, and also up the Saskatchewan river south of there.

They are likewise well exposed to the west of Edmonton along the Pembina and Lobstick rivers, and on Wolf creek still farther west.

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[1]Dowling, Can. Geol. Surv., Ann. Rep. XV, Part F, 1904.
[2]See Memoir 24, p. 79.

Those around Edmonton as a rule give trouble in moulding and drying, and are not satisfactory, but those found to the westward at the points mentioned are well worth working, since they represent materials that can be used for common, pressed, and paving brick, drain tile, fireproofing and probably in some cases sewerpipe.

Tests of these Edmonton shales will be found in Memoirs 24 and 25.

Shale exposures should also be looked for on the Red Deer river within the limits underlain by the formation, and on the Bow river near Crowfoot crossing.

A narrow belt of the Edmonton formation occurs along the foothills, and passes west of Cowley on the Crows Nest branch of the Canadian Pacific railway, and west of Cochrane on the main line of the same road.

The Tertiary formations overlie the Edmonton series and form a broad belt extending from somewhat north of the Grand Trunk Pacific west of Edmonton, southward almost to the International Boundary.

The formation consists of shales and sandstones often alternating in rapid succession. Outcrops are scarce, as the formation is heavily and extensively covered by Pleistocene sands and gravels.

It includes the shale areas examined at Red Deer, Calgary, Sandstone, and Pincher creek near Pincher.

Tests of the shales collected from these areas in 1910 and 1911 have shown: (1) that the formation carries a number of good shale deposits; (2) that the quantity of interbedded sandstone layers varies from point to point; (3) that different beds of the shale vary in their refractoriness, the fusion point of the different ones ranging from cone 3 to 15; (4) that they are usually red burning.

This is an important shale formation, and it carries material suitable for making common or pressed brick, fireproofing, and in some cases even sewerpipe. Before a plant is located, however, the property should be carefully prospected and the material properly tested.

The formation is often covered by gravel, so that shale outcrops are scarce, but in many instances the material lies at no great distance below the surface.

MOUNTAIN REGION.

This includes the region bordered on the east by the Great Plains, and on the west by the Coast Range, and does not contain such extensive clay resources as the Great Plains area.

Shales of suitable character for the manufacture of clay products are rare, either because the deposits of argillaceous material are too siliceous, or else because they have been metamorphosed to a slaty or schistose condition.

There are several localities, however, in which promising shale beds are known.

Beginning at the north, shale beds are found associated with the Cretaceous coals in Jasper Park, which may prove useful for brick manufacture, but they have been so little developed that no definite information can be given regarding them.

Along the main line of the Canadian Pacific at Canmore and Bankhead (near Banff), there are shale beds with coal, but they are too sandy and coaly in their character.

In the Crowsnest pass shales which can be employed for dry-pressed brick are found in the Benton, near Blairmore. Others found near Sentinel can be used for sewerpipe manufacture. Southeast of Blairmore still other Benton shales are known which if present in sufficient abundance are worth utilizing for pressed brick.

The shales around Fernie have not proved of value.

Some in the Princeton coal basin are of possible value for making second-grade firebrick.

In the Nicola valley, there are shales associated with some of the coal beds, that could be utilized for brick and fireproofing.

Of the surface clays there are a large number of small deposits, that could be employed in common-brick manufacture. One of the most extensive is that found in the Nicola valley between Merritt and Nicola, which is adapted to brick and tile making.

Other less extensive deposits occur near Kamloops, Creston, in the Okanagan valley, etc.

The most remarkable surface clay deposit found in the mountains, however, is the vast silt deposit occurring in the upper Columbia valley and described in the present report, and for which the only use suggested is the manufacture of scouring brick. It works well for this purpose.

PACIFIC COAST REGION.

This includes the territory lying west of the Coast Range, and while limited in the extent of its clay resources, contains a considerable variety of plastic materials. These may be grouped under the following heads.

(1) The shale deposits of Sumas mountain. These form an important series of varying character, adapted to the manufacture of pressed and paving brick, firebrick, fireproofing, sewer-pipe and roofing tile.

There is no other locality thus far discovered in Canada which contains such a variety of materials. Two factories are using the shales at the present time.

(2) Plastic surface clays of the lower Fraser valley. These are red-burning clays, which form the basis of a thriving brick and tile industry. They are worked at New Westminster, Port Haney, Ruskin, etc.

(3) The Northumberland shales of the Cretaceous formation on Vancouver island. These in general represent hard and often gritty shales, which are red burning, but do not possess much plasticity. With proper care they can be made into bricks.

(4) Glacial clays on southern Vancouver island and some of the smaller islands between Vancouver island and the main land. These are red burning and utilized for brick.

(5) Residual fireclay, found near Kyuquot or northwestern Vancouver island.

(6) Deposits of glacial clay scattered along the coast, and which could be worked later to supply the Prince Rupert market.

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CONCLUSIONS.

After having covered most of the accessible portion of the territory of the western provinces, I think it is safe to say that the different formations mentioned carry a variety of clay resources which it will pay to develop.

There are areas which are still more or less inaccessible, and some of these contain undeveloped coal fields. Possibly some of the coal seams will be found to have shales associated with them, that are of refractory character.

METHODS OF TESTING.

The samples collected in the field were taken with all possible care, so as to represent the average of the bed tested.

When received in the laboratory they were put through a crusher, set to $\frac{1}{10}$ inch. In the case of soft surface clays this was sufficiently fine to cause them to disintegrate and slake when mixed with water. The tougher, harder shales, like those from Vancouver island, were sifted through a 20 mesh sieve and only the siftings used, otherwise the mass would not have been sufficiently plastic.

In order to test the drying qualities, full sized brick were moulded by hand and placed at once in a hot air bath.

Another sample was put through an annular die, and pressed into a small pipe.

A third sample was mixed for the tensile strength test, the figures given representing the average of 10 or 12 samples.

A fourth lot was made up into bricklets $4 \times 1 \times 1\frac{1}{2}$ inches. The average of ten of these was measured for the air shrinkage.

After air drying the bricklets were run in ten hour burns to cones 010, 05, 03, and 1. These were fired in an oil kiln. The burns above this were made in a gas kiln.

After each burn the bricklets were measured for linear air shrinkage, absorption, colour, and hardness.

In many cases a fifth sample was usually moulded into dry-press bricklets, which were burned in the same manner as the wet-moulded ones, and also tested in a similar way after burning.

As all persons consulting this report may not be familiar with the pyrometric cones referred to in the fire tests, it may be explained that they represent a graded series of mixtures of definite chemical composition, each member of the series having a theoretic melting point.

As the temperature of the kiln rises the cone begins to soften as its theoretic melting point is approached, and then bends over until the tip touches the base. This occurs at the temperature of fusion.

Pyrometric cones are not to be used for measuring temperature, although as a rule they fuse fairly close to their theoretic melting point if the temperature is raised slowly, and kiln conditions are normal. Their main use is to measure heat effects.

The theoretic fusion points of the cones referred to in this report are as below:—

Cone	Centigrade	Fahrenheit
010	950°	1742°
05	1050°	1922°
03	1090°	1994°
1	1150°	2102°
3	1190°	2174°
5	1230°	2246°
9	1310°	2390°
20	1530°	2786°

MEDICINE HAT AREA.

In an earlier report on the western provinces[1], reference was made to the shales of the Belly River series found in the Medicine Hat region, as well as to the surface clays of Pleistocene age, and the clayworking industry based on these materials. Tests of the shales near Coleridge, Redcliff, and other points around Medicine Hat were also given.

Additional tests, especially of the shales found in Bulls Head Creek valley, will be found in the report covering the field season of 1912. These last have not yet been developed, although

[1] Ries and Keele, Preliminary Report on Clay and Shale Deposits of the Western Provinces.

they should be. One reason for this may lie in the fact that no natural gas well has as yet been developed in the vicinity of these deposits, although there is perhaps as much chance of finding the gas there as at Medicine Hat, Redcliff, and Bow Island.

Between the summers of 1911 and 1912 there have been active developments going on at the Medicine Hat district as follows:—

The Purmal and Pruitt plant, now known as the Purmal Brick Co., has been rebuilt and enlarged since the fire which destroyed it. The plant has been equipped with both dry-press and stiff-mud machines, and drying tunnels, in addition to up-draft brick kilns. The clay which they continue to use is the silty laminated clay found in the bluff just back of the works. This contains pockets of gumbo clay and pebbly lenses, but these are eliminated as far as possible. A section of the face of the bank as it appeared in 1912 is given in Fig. 1.

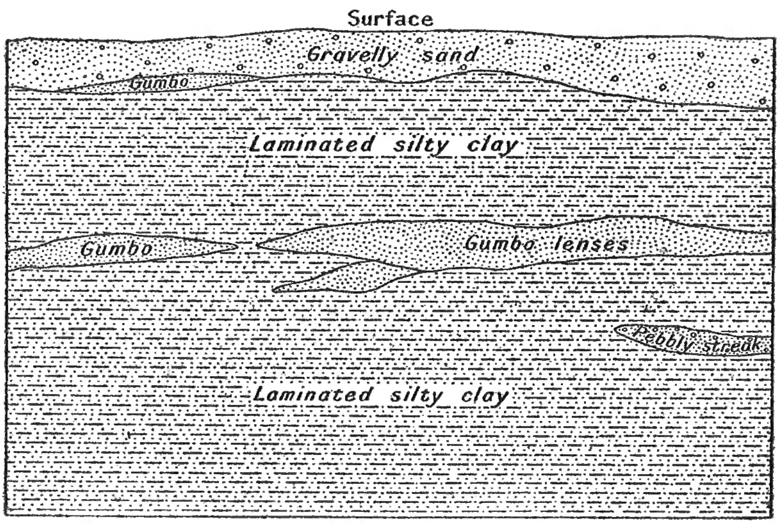


Fig. 1. Section of clay bank, Purmal Brick Co., Medicine Hat, Alberta.

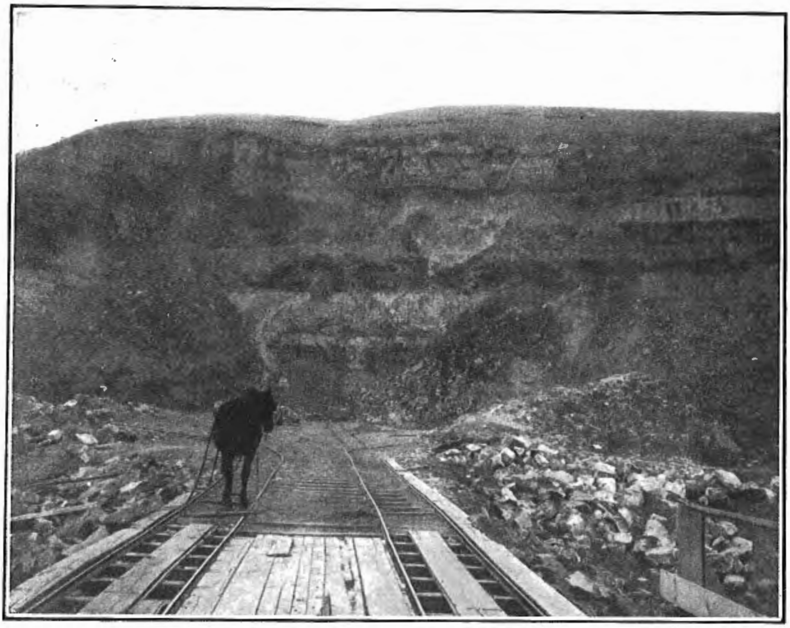
The Alberta Clay Products Company, also located at Medicine Hat, has continued in active operation. The output has been mainly fireproofing, but in addition sewerpipe and pressed brick have also been made. The Company has greatly enlarged its shale bank excavation at Coleridge, and the illustrations in Plates I and II give some idea of the present extent of the operations. The different beds of shale show up rather clearly in the view. Plate I shows an excavating machine that the Company attempted to use, with not much success, however, as it is better adapted to level ground. In addition the Company has also been shipping in some shale from Sentinel, near Coleman, in the Crowsnest pass. This material mixed with some of the local shale from Coleridge is said to have been tested for sewer-pipe with good results. The plant has also been enlarged by the addition of a number of down-draft kilns.

A new plant, that of the Redcliff Clay Products Company, has also been put in operation at Redcliff. The Company is working a bed of Belly River shale, about 15 feet thick, that lies about 18 feet below the surface. At the time of my visit it was worked by underground methods, the shale being hoisted up an incline to the plant. The material was ground in a dry pan, screened, and moulded in a dry-press machine. The plant was equipped with two permanent kilns, and seven temporary ones. Care has to be taken in burning the clay to prevent checking.

A new and interesting addition to the clay working industry of the Medicine Hat region is the establishment of a pottery, known as the Medicine Hat Potteries. This began operations in the autumn of 1912, and the product includes flowerpots made from the Redcliff clay, and earthenware pots, crocks, demijohns, ornamental flower pots, etc., made from a mixture of Redcliff clay and clay from Spokane. The Company is also utilizing the Spokane clay exclusively for making glazed spittoons and hotel china. The fuel used for burning is natural gas. It is possible that later some of the Dirt Hills stoneware clays may be used. These were described in Memoir 24, page 84.

During the field season of 1912 a visit was made to a large coulee, known locally as the Big Coulee, which is located about 3 miles west of the City Hall, Medicine Hat, and on the north side of the Saskatchewan river.

A section of some thickness is exposed here, and consists of differently coloured shales, with occasional beds or thin layers of lignite, and sandy streaks.



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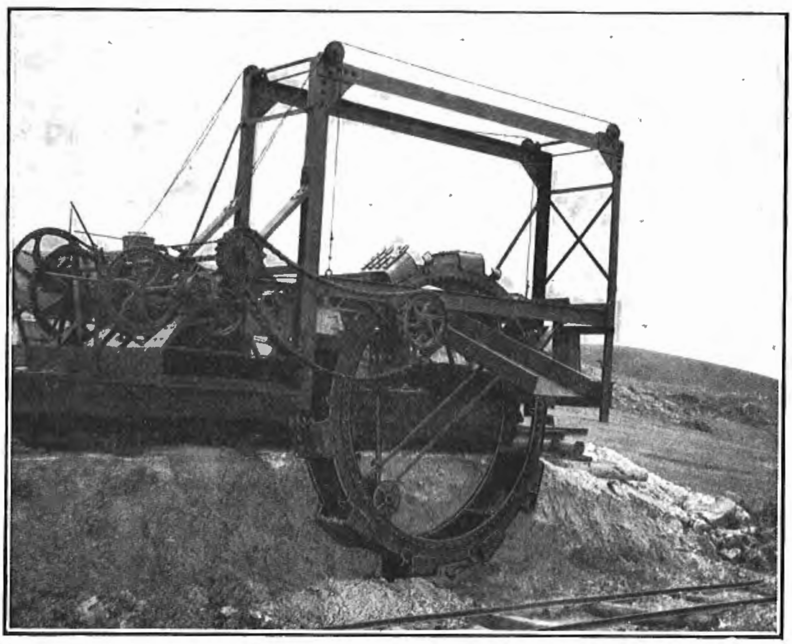

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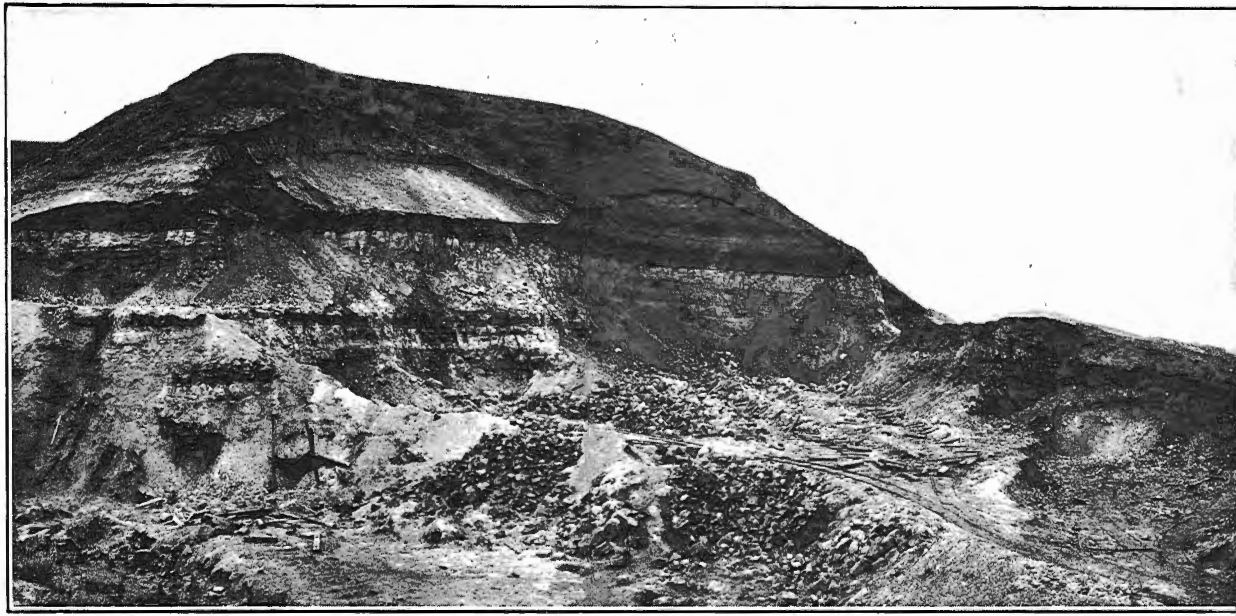
A. Second opening of Alberta Clay Products Company, near Coleridge, Alta.
B. Excavating machine, pit of Alberta Clay Products Company, near Coleridge, Alta.

PLATE II.



First pit, Alberta Clay Products Company, Coleridge, Alta.

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Near the top of the section, the banks of the coulee recede somewhat, and it is about three-fourths of the way up that a bed of fairly clean shale, probably 25 feet thick, outcrops. Several trenches were dug in the face of this material in order to obtain an average sample, the tests of which are given below.

This sample (Lab. No. 1857) was taken from near the top of the big coulee, from a bed probably 25 feet thick, containing a few thin sandy layers, and lignitic streaks.

It had good plasticity and worked up with 24 per cent of water. The average air shrinkage was 6·6 per cent and the average tensile strength when air dried was 281 pounds per square inch, which is fairly high. The fire shrinkage is low, and the absorption is rather higher than is desirable in a common brick, as can be seen from the following figures:—

Cone	Fire shrinkage	Absorption
010	0	21·00
05	7	17·50
1	7	17·00
6	Fused	.....

From these tests it will be seen that the clay is somewhat more open burning than most of the clays which have been tested from this vicinity and from the Belly River formation. The clay burns to a brownish colour. A sample flowed through an annular die smoothly and without cracking, and burned to cone 1 showed 7 per cent fire shrinkage, but was not steel hard.

This clay could be used for common brick, and possibly also for fireproofing, but its colour after burning is not good enough for pressed brick.

Along the river at the entrance to the Big Coulee are outcrops of shale, of a bright red colour, showing a peculiar columnar jointing and known as the burnt cliffs. It has been assumed to have some economic value, but the material (Lab. No. 1856) is a very sandy shale, of poor plasticity, and not worth working.

BOW ISLAND.

Bow Island lies within the Belly River shale area, but up to the present time no attempt has been made to exploit the shales in this region, although they are easily accessible, and could be dug without much difficulty.

From Bow Island station northward to the Saskatchewan river, the country is grass covered, and there is no good chance to obtain a section until the river is reached. Even here, although there is a steep slope bordering the river, the wash conceals most of the section. Ditching the bank would probably expose the beds with comparatively little trouble, so that a large sample could be obtained.

The locality especially visited was at the river, about 4 miles north by northwest from the station and at a point where a lime kiln and gas well are located. Here the slope is about 75 feet high, and capped by four small hills, in which a somewhat imperfect section can be obtained.

These sections indicate the usual characteristics of the Belly River formation, that is, layers of shales, sands, and some lignites. One of these sections, for example, shows:—

Sand with scattered pebbles................	10–15 feet.
Clay shale..............................	3 feet.
Grey sand..............................	2 feet.
Yellow sand............................	3–4 feet.
Clay shale..............................	..

This represents the upper part of the 75-foot slope. The lower portion of the section, though not sufficiently exposed to give the thickness of the beds in detail, shows a continuation of the shale beds, and also some thin seams of lignite.

Several samples were taken of the shales to supply some clue to their physical characteristics, and these tests are given in detail below. It will be noted from these tests that the samples are all red burning, not of high refractoriness, and that all have a rather high air shrinkage. On account of the last point it would no doubt be found desirable to add some of the sandy beds to the shale. Indeed this would probably be compulsory, as the sandy layers could not be economically separated from the shale.

The first sample tested (Lab. No. 1851) was from the hill just up stream from the trail leading down to ferry landing. This material alone is very plastic, but shows a tendency to crack somewhat in drying, which is not rare in the Belly River clays and shales. These cracks become emphasized in burning. The air shrinkage is also high, viz., 11·3 per cent, and in order to reduce it the clay should be mixed with a more sandy material. It burns to a bright cherry red colour, and as far as its colour-burning qualities are concerned is one of the best samples tested from the Belly River series of this region. When moulded wet-mud it gave the following results:—

Cone.	Fire shrinkage.	Absorption.
010	1·6	13·70
05	5·7	3·90
1	6·0	·60
3	Fused	....

The fire shrinkage, it will be seen, is low at cone 010, and not very high at cone 05. The absorption is not unreasonably high either at cone 010. The clay burns steel hard at 05. Better results would no doubt be obtained by moulding a clay of this sort dry-press.

The next sample was from the fourth hill, down stream, from trail leading to ferry landing. This shale (Lab. No. 1852) is of good plasticity and did not crack in drying, although it had a somewhat high air shrinkage, viz., 10·6 per cent.

It burns to a red colour, but not as bright as No. 1851. Neither the fire shrinkage nor absorption are excessive as the following figures will show:—

Cone.	Fire shrinkage.	Absorption.
010	1	12·00
05	6	3·70
1	7·7	·30
3	Nearly fused	....

It will be seen from the above tests that the clay is practically vitrified at cone 1.

The third sample (Lab. No. 1853) was a 3-foot layer shown in section given above, and was from the hill just back of the lime kiln.

This is a plastic but gritty clay, and on account of its grittiness the air shrinkage, 9·6 per cent, is somewhat lower than in the preceding ones from the same locality. The clay burns to a good hard body even at cone 010, but the colour is not very good, and the soluble salts cause some scumming. Fire tests gave the following figures for absorption and shrinkage.

Cone.	Fire shrinkage.	Absorption.
010	0	11·60
05	0	8·60
1	1·4	8·8

This clay is less dense burning than the other two. It would probably work dry-press.

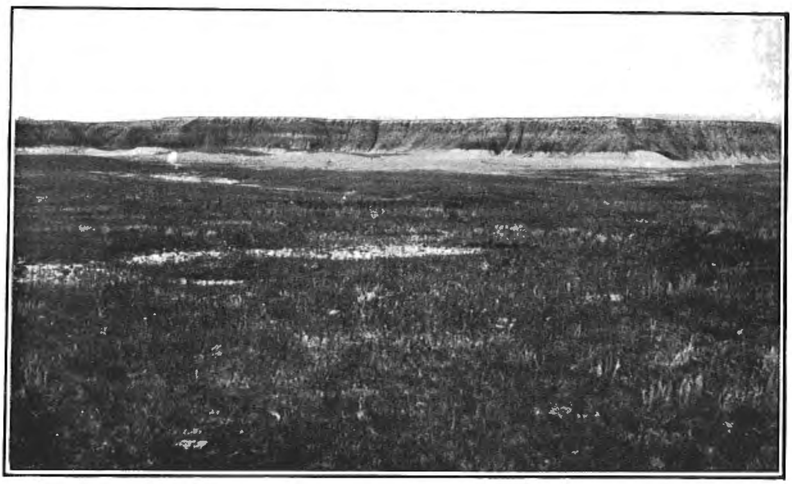
The fourth sample (Lab. No. 1854) was from above the upper coal seam on the hill just east of the trail leading to ferry landing.

Like the other samples from Bow Island, this has a somewhat high air shrinkage, viz., 9·6 per cent. It is fairly plastic and does not crack in air drying, but is not very dense burning. Even at cone 05 the colour is light red, although bright. The fire shrinkage at cone 010 is 0·3 per cent and the absorption 17·90 per cent, while at cone 05 the fire shrinkage is 1 per cent and the absorption 15·20 per cent. Aside from the somewhat high air shrinkage, this is a good red brick material. It could probably be worked dry-press, but alone does not seem to recommend itself for fireproofing.

GLEICHEN.

About one-half mile west of Gleichen, on the main line of the Canadian Pacific railway, east of Calgary, and to the north of the track, there is one of the few shale exposures (Plate III) seen between Calgary and Medicine Hat. The locality is, according to the geological map, just about on the boundary line between the Edmonton and the Paskapoo, but probably belongs to the former.

PLATE III.



View of shale bank west of Gleichen, Alta.

The exposure is not a very large one; the shale crops out in the cut bank of a small stream, and the face is about 25 feet in height. The section is approximately as shown in Fig. 2.

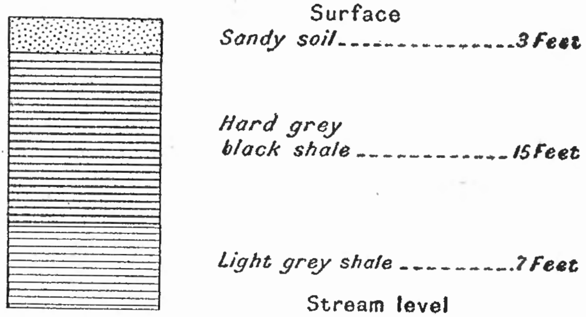


Fig. 2. Section in shale bank, west of Gleichen, Alberta.

Samples of the two beds were tested separately and the results of these are given herewith.

The sample from the upper bed (Lab. No. 1875) is a fairly plastic clay, but tends to crack in air drying. Its air shrinkage is 7 per cent. The clay burns to a reddish brown colour. At cone 010 the fire shrinkage was 1·6 per cent and absorption 14·79 per cent. At cone 03, the fire shrinkage was 4 per cent, and absorption 11·70 per cent.

The shale from the lower bed (Lab. No. 1865) is slightly calcareous, but worked up to a mass of good plasticity with 34 per cent of water. Its air shrinkage of 12·3 per cent was excessive, and its average tensile strength of 50 pounds per square inch was lower than one could wish for. It is likewise not surprising that a clay with such high air shrinkage should crack when made up into large bricks and dried rapidly. The high air shrinkage also formed small cracks which caused a weakness in the briquets. The clay flows smoothly through a die.

The fire tests were as follows:—

Cone.	Fire shrinkage.	Absorption.
010	1·2	11·90
05	6·0	1·30
1	6·3	1·00
4	Fused	....

The bricklets burned steel hard and to a light-red colour at cone 010, and a deep red at cone 05. They all showed small cracks, so that the clay could not be used alone.

When moulded dry-press, the clay gave 6·0 per cent fire shrinkage, and 9 per cent absorption at cone 05, but showed a tendency to develop fire checks.

Comparison of these two materials indicates that the upper one in the section shows a tendency to crack in the air drying, as does also the lower one, but the latter burns to a denser body at cone 03. It is suggested, therefore, that the two be not only mixed, but that to the mixture there be added some of the loamy surface clay which can be easily obtained in the vicinity. This would reduce the air shrinkage, and might also reduce the cracking in drying. If the latter trouble still exists after the loamy clay is added, the next thing to do would be to try moulding the clay dry-press.

We have no definite data as to how far this shale deposit extends, but it may be quite extensive. The reason why this locality is emphasized is because there is no brick plant between Redcliff and Calgary. Of course it might be argued that there is little or no demand for bricks in this stretch of the line, but there is some. Moreover, the Calgary market is not too far away for shipment. It may be argued, of course, that the Tertiary shales are found close to Calgary, and will supply the demand. This is true in a sense, but these shales are open to the objection that they contain abundant sandstone layers at most points, and these have to be thrown out in the mining. Before a plant is erected to work the shale at Gleichen, the extent of the deposit should be well tested, and the material should also be tried out in a regular brick machine.

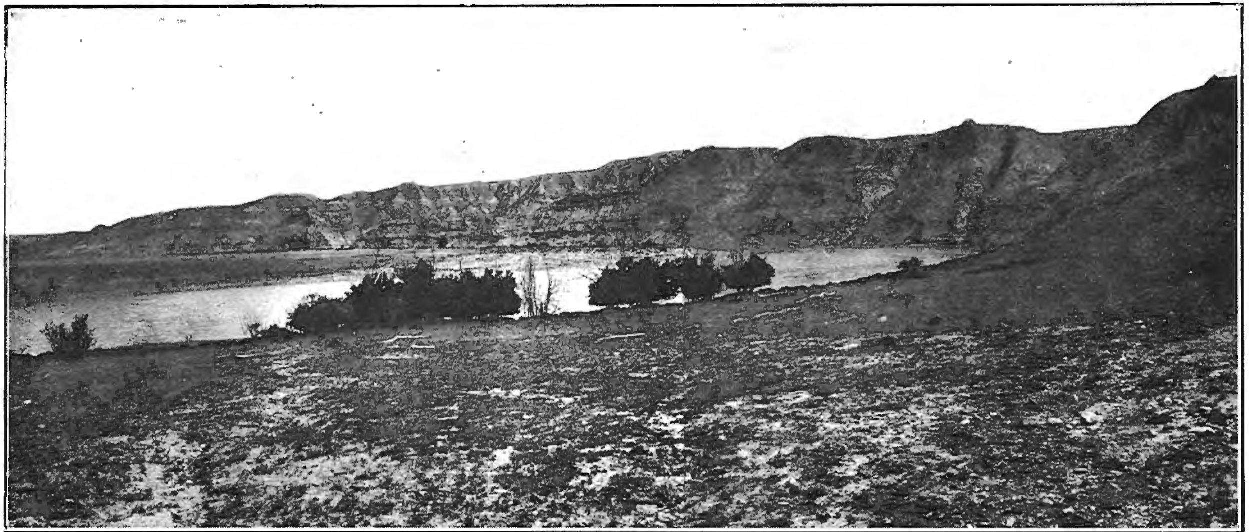
No other clay was tested from the vicinity of Gleichen, but it was said that good clay occurs on H. B. Biggs' ranch at Rosebud, 25 miles from Gleichen.

LETHBRIDGE DISTRICT.

In a previous report[1], attention was called to the Belly River shales at Lethbridge. Their generally carbonaceous char-

[1]Memoir 24, p. 59, 1912.

PLATE IV.



Bend of Belly river, seven miles northeast of Lethbridge, Alta.

acter was commented on, although one deposit slightly better than the rest was tested. This was from the river level, near the eastern end of the wagon bridge across the Belly river.

Realizing the possibility of variation in the character of the shales of this formation, the district was revisited last summer in order to obtain some further sections up and down the river.

Northeast of Lethbridge.

Along the Belly river, east of Diamond City, at a big curve (Plate IV) in the river, a rather deep coulée gives a section that is probably 100 feet in height.

At the base of the section there are beds of sandstone, but then follows about 75 feet of shale with finely banded sandstone layers, this portion being represented by sample Lab. No. 1870.

Over this is about 20 feet of shaly material and sand, represented by sample Lab. No. 1868.

The sandstone at the bottom of the section is of no value for the manufacture of clay products, but the other two could be used as the tests below indicate.

The details of the fire tests follow.

Shale from Top of Section Northeast of Lethbridge (*Lab. No. 1868*). This shale, although somewhat sandy, is nevertheless fairly plastic when mixed with water. Its average air shrinkage was 8 per cent, and average tensile strength 60 pounds per square inch. The clay burns dull-brownish red, and becomes steel hard at cone 05.

Fire tests of the wet-moulded bricklets gave the following results:—

Cone.	Fire shrinkage.	Absorption.
010	·3	12·70
05	·3	9·60
1	1·0	8·1

For common brick manufacture this material is to be regarded as satisfactory although the colour after burning is not very good. I should not recommend it for pressed brick.

Shale from Middle of Section Northeast of Lethbridge. (*Lab. No. 1870.*) This shale is also fairly plastic. No complete test was made of it, however, only a few burns being carried out to see its behaviour on firing.

The air shrinkage was 7 per cent. The clay burns pinkish and is steel hard at cone 05. At cone 010 the fire shrinkage was 0 and the absorption 19·4 per cent. At cone 05, the fire shrinkage remained the same, with an absorption of 18·5 per cent. The material is to be graded as a brick clay.

Junction of Belly and St. Mary Rivers.

The Belly and St. Mary rivers join about 7 miles southwest of Lethbridge, and in the banks bordering these two streams some imperfect sections of the Belly River formation can be obtained. Thus on the east side of the Belly river, near its junction with St. Mary river, there is a large coulee, containing the remains of a railway track, in which some of the beds are exposed. About 200 feet up the coulée the section shown in Fig. 3 is seen.

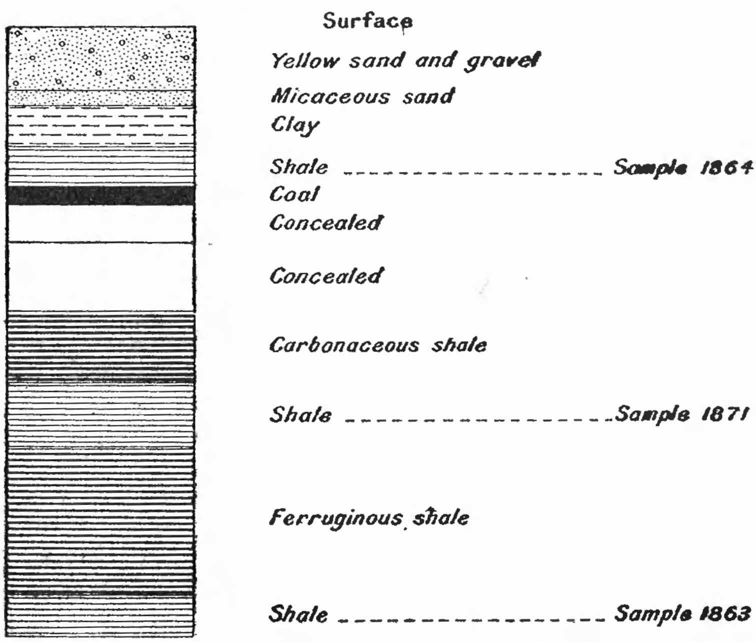


Fig. 3. Section in face of coulée opposite junction of Belly and St. Mary rivers, Alberta.

At first glance this section does not appear very promising, but in a district like this where good clays are scarce, where bricks are high priced, and have to be brought a long distance, it is possible to utilize materials which could not be economically handled in some other area. The entire section was not sampled, but only certain shale beds were tested, their laboratory numbers being indicated in the section given in the figure above referred to. These tests are given below, and from them it will be noted that some of the shale beds are workable. It might pay to work some of these shales by drifts and underground chambers as has been done in some parts of the west, especially if the shales were worked for dry-pressed brick, and the industry was conducted on a small scale. Or, an alternative would be to work the upper part of the section down to and including sample 1864. This, I think, could be done satisfactorily for common brick making. I incline to the belief that it would certainly give better results than the surface silts that have been used around Lethbridge.

The properties of the samples tested are as follows:—

Sample No. 1864. This shale worked up with 28 per cent of water to a fairly plastic mass, whose average air shrinkage was 7·1 per cent, and average tensile strength 55 pounds per square inch. The latter is not very high. The clay flowed through a 3-inch die without cracking, but large bricks could not be rapidly dried without checking. They gave no trouble in slow drying. The clay showed evidence of soluble salts which would have to be counteracted by using barium carbonate or chloride, if the material is to be used for face brick.

Both wet-moulded and dry-pressed brick were tried, and the results of these tests are given below.

Wet-moulded Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	1·2	14·10
05	8·3	1·90
1	8·8	1·80
3	Beyond vitrification	....
4	Fused	....

Dry-pressed Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	2	15·60
05	3·3	10·20

The conclusions are that the clay could be used for dry-pressed brick if well ground and slowly burned. It could be used for common brick if the air shrinkage is somewhat reduced. It is worth trying for fireproofing manufacture. The dry-pressed bricklets gave a better red in burning than the soft-mud variety.

Sample No. 1863. This is a fairly plastic shale, which worked up with 29 per cent of water to a mass that flowed through a die without cracking. The average air shrinkage was 8·7 per cent and the average tensile strength was 172 pounds per square inch. The latter is good, but the former is rather high; it could probably be reduced by mixing in some of the more sandy beds of the vicinity. The air drying of the wet-moulded bricklets could not be rushed, as they showed a tendency to crack. The shale gave a good body, with red colour and good ring at cone 010, when moulded wet. It also gave a fair dry-pressed brick at the same cone.

Burning tests of the two classes of bricklets were as follows:—

Wet-moulded Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	1·3	17·20
05	5	6·70
1	7·7	6·6

Dry-pressed Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	2·3	16·00
05	3·0	11·00
1	7·3	8·40

The clay gave good results. It could be used for common brick if some more sandy material were added to it to reduce the air shrinkage, and by the same means, for drain tile. Alone, it can, I believe, be used for dry-pressed brick, and it will be noticed from the tests of this nature quoted above, that the fire shrinkage is low and absorption not high. Moreover, the product was steel hard at cone 05.

Sample No. 1871. This bed of material is rather lean and granular, and has an air shrinkage of 5 per cent. It was sufficiently plastic, however, to be wet-moulded. The bricklets so made were then burned at three cones as follows:—

Cone.	Fire shrinkage.	Absorption.
010	3·6	27·1
03	11·0	11·1
1	11·6	11·7
6	Fused	....

The clay does not burn to a very good colour, but it could be used for common brick.

Sample No. 1874. This is a moderately plastic clay, which is probably plastic enough to flow through a die. Its air shrinkage is 7·5 per cent, it burns steel hard at cone 05, and gives a reddish brown product. At cone 010 the fire shrinkage is 0·5 per cent and absorption 20·7 per cent. At cone 05 the fire shrinkage is 2 per cent and absorption 16·2 per cent.

The material could be used for common brick, but I question its value for anything else.

Lethbridge to Coutts.

A trip was made along the railway from Lethbridge to Coutts, to ascertain the possibility of finding any shales in this territory.

The country south of Lethbridge is very gently rolling with no exposed section, and even in the brook just south of Sterling, no shales were found. Neither did the irrigation ditch to the southward extend below the drift. Boulder clay cuts occur along the line north of Tyrrell. At Milk river, where it is crossed by the railway, there are small cuts both up and down stream, but they expose no shale. None is exposed either in the narrow gorge of Rock creek. About one-half mile from Monarch there is an old brick yard, but the material used there was surface clay.

CROWSNEST PASS REGION.

During the work on the clays and shales of western Canada, care has always been taken to follow all clues which might lead to the discovery of good clays. The reason why clays or shales have been specially sought for in this region, is because there are many shale deposits in the coal measures sections, and it has been hoped that some of these might prove profitable. Another reason why the discovery of good clays or shales would be important here, is because of the coking industry, and also the smelting industry of this region, which demand a considerable quantity of refractory bricks.

Many rumors of the occurrence of fireclays have been looked into, but these have usually proved to be baseless. Such rumors usually arise from the fact that many people, and even mining men, have erroneous conceptions regarding the appearance and properties of a fireclay. For this reason it may not be out of place to make a few statements on the subject at this place.

Fireclays are not necessarily closely associated with coal beds. They sometimes underlie them, or even overlie them, but they may also occur in regions in which there is not one ounce of coal to be found. All clays under coal are not fireclays. A wide-spread belief that they are, has led many to call all under clays, fireclays. Indeed, so firmly rooted and wide-spread has this popular theory become, that it is often difficult to convince people to the contrary.

A fireclay may be almost any colour from black, through grey, blue grey, pink, etc., to white, so that colour is no evidence of its refractoriness.

A fireclay may be soft and plastic, it may be fairly hard and solid like shale, or it may be dense and flint like, yielding the variety known as *flint clay.*

It will, therefore, probably be seen from what has just been said that it must be practically impossible to tell a fireclay on sight, and this indeed is true.

A chemical analysis does not always serve as a satisfactory guide, so that a fire test is the only satisfactory one to make.

There is still another point to be emphasized, viz., that shales can be used for a variety of clay products, and that the value of the shale for such purpose depends, usually, primarily on its giving a plastic mass when ground and mixed with water, so that it can be moulded into the desired shape. But shales differ greatly in this respect.

Many shales may be hard when fresh and unweathered, but all such do not grind down easily and form a plastic mass when mixed with water. The shale found outcropping near the coal mines at Morrissey, or at Coal Creek near Fernie, is hard, and gritty, and the grains are cemented together. That found near Sentinel is hard, but still grinds up to form a plastic mass with water.

The appearance of the shale on a weathered outcrop sometimes gives a clue, for if the material weathers slowly, and at most breaks down to hard scaly fragments, it is questionable whether it will work up to a very plastic material. Much of the Pierre shale of Manitoba and Saskatchewan is illustrative of this character. On the other hand, if a shale weathers down easily to a plastic mass, it is likely to give similar results when ground and mixed with water.

A last point to be mentioned in this connexion is that the shale associated with coal seams is sometimes very carbonaceous in its character, and has to be carefully and slowly fired in order to eliminate the carbon before vitrification begins.

With these preliminary remarks we can now turn to the shales which were examined from the Crowsnest Pass area. The localities will be referred to from east to west.

South Fork Area.

During the season of 1912, Mr. J. D. Mackenzie of the Geological Survey sent in two samples of clay from the South Fork. One of these, No. 1908, is known as the northeast seam on South Fork. The other, 1909, which is said to come from the other branch of an overturned syncline, is labelled as sample No. 1 from near Jackson creek, a branch of South Fork river. These two samples were first tested separately.

The material (1908) is a very plastic, but granular clay, which mixed up with 31 per cent of water to a very plastic mass, with 8 per cent air shrinkage and 55 pounds per square inch average tensile strength. Large bricks cracked in rapid drying. It burned to a cream coloured brick at first, and later to a greyish brick. The materials showed a low fire shrinkage up to cone 1 at least, and fused at cone 8. It was steel hard at cone 05.

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

Cone.	Fire shrinkage.	Absorption.
010	0	15·60
05	·3	15·80
03	1·0	13·20
1	1·0	14·20
8	Fused	....

Unless hard-burned, the material slaked badly after standing for several days in the air.

The other clay (1909) had good plasticity but not as much as 1908. It took 32 per cent of water to mix it up, and had an air shrinkage of 7·6 per cent. It also cracked if dried rapidly. The average tensile strength was 55 pounds per square inch. Burned at cone 010 the clay seemed to be all right after coming from the kiln, but disintegrated after several days exposure to the air, and in order to prevent this it is necessary to either soak the brick as soon as it comes from the kiln, or else burn it harder. The clay does not shrink much until when near its vitrifying point, and then softens rapidly, fusing about cone 8.

The wet-moulded bricklets gave the following results:—

Cone.	Fire shrinkage.	Absorption.
010	1	16·50
05	2	12·70
1	1·7	11·30
8	Fused	....

The clay burns buff at first and grey at a higher cone as at 3.

The following is an analysis of clay No. 1909:—

Silica (SiO_2)	59·23
Alumina (Al_2O_3)	20·00
Ferric oxide (Fe_2O_3)	3·36
Lime (CaO)	3·86
Magnesia (MgO)	1·51
Alkalies (Na_2O,K_2O)	2·34
Titanic oxide (TiO_2)	0·21
Ignition	8·03
	98·54

When the two samples were first received, their appearance was much like some of the fireclays from the Dirt hills in Saskatchewan, and it was suggested that they might be fireclays. This view was abandoned when they began to air slake after being out of the cone 010 burn but a few days.

A mixture of 1908 and 1909 was tried. This had better working qualities, but slaked just as badly after burning, unless burned to cone 05.

Since these clays occur in the Benton formation, it was decided to try a mixture of these clays with black Benton shale from near Blairmore. A mixture (Lab. No. 1911) was, therefore, made up consisting of 1886, 50 per cent; 1908, 25 per cent; 1909, 25 per cent.

It worked up with 30 per cent of water to a mass that was fairly plastic, but not as much so as either 1908 or 1909 alone. The average air shrinkage was 5 per cent and the average tensile strength 50 pounds per square inch. The mixture did not slack at cone 010, as 1908 and 1909 did. It burns to a buff coloured body with good ring, but not very low absorption. Up to cone 1 the fire shrinkage was 0. The percentages of absorption were, respectively: at cone 010, 20·90 per cent; cone 05, 21·40 per cent; and cone 1, 20·8 per cent. It was viscous at cone 7.

The mixture could probably be used for face brick.

There was next tried a mixture (Lab. No. 1912) of 50 per cent 1885, and 50 per cent 1908. This gave a mass of good plasticity with 30 per cent of water. Its air shrinkage was 6 per cent and average tensile strength 65 pounds per square inch. It gave the same trouble as 1908 and 1909 when burned at cone 010,viz., that it disintegrated after several days exposure to the air. The colour after burning at cone 05 was grey. At cone 05 the fire shrinkage was 1 per cent, absorption 13·50 per cent. At cone 3 the bricklet was beyond vitrification. At cone 7 it was viscous.

The material could probably be used for face brick.

Another sample sent in by Mr. Mackenzie represents one of several 10 to 20-foot bands exposed in Mill creek in the northeast quarter section 11, township 5, range 2, west of principal meridian, in southwestern Alberta.

The beds dip steeply southwest, and are underlain by fine, grey-blue limestone.

The sample as tested (Lab. No. 1913) was a mixture of coarse and fine material, and made up of 50 per cent larger than 20 mesh and 50 per cent under 20 mesh.

Mixed up with 22 per cent of water it appeared sandy at first, but after thorough kneading developed good plasticity. It burned to a reddish body, which deepened considerably in colour at cone 1. The average air shrinkage was 5·6 per cent and average tensile strength 55 pounds per square inch. The clay moulded without difficulty, and could be made to flow through an annular die.

The wet-moulded tests gave:—

Cone.	Fire shrinkage.	Absorption.
010	1·0	17·00
05	2·0	14·30
1	2·7	5·5
3	Viscous	....

It is probable that in addition to being used for brick, this material could be used at least in part as an ingredient of fireproofing. It is not to be recommended for paving brick, and does not stand enough heat for sewerpipe.

Similar shales were seen at the railway trestle over Mill creek in the northeast quarter section 12, township 6, range 2, west of 5th principal meridian.

Frank Area.

In last year's report reference was made to some shales outcropping on the northern edge of the Frank slide, and near the town of Frank. Since then further search was made for shales in this region. The bituminous coal mines at Bellevue were visited, but nothing found as the roof is sandstone with shaly streaks, and the floor is sandstone. At Hillcrest the same conditions were found.

Blairmore.

The only shales which have been used near Blairmore are the Fernie shales employed for making dry-pressed brick. These were referred to in an earlier report.[1]

The Benton shales are well exposed about 2 miles southwest of Blairmore, along the dam of the reservoir where the town water supply is stored. The shales strike N. 10° W., and dip 55° S.W. About 100 feet of shale is exposed, resting on the Crowsnest volcanics, but the total thickness of the shale is very much greater than the figure mentioned above.

The material (Lab. No. 1886) is a black, slaty shale that worked up with 0·15 per cent of water to a mass of poor plasticity, whose air shrinkage was 2·7 per cent and average tensile strength 32 pounds per square inch. It burned to a buff coloured body, of rather porous nature.

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

Cone.	Fire shrinkage.	Absorption.
010	1·0	25·30
05	1·0	24·00
03	1·0	25·00
1	1·0	25·00
7	Fused	....
9	Slagged	....

[1]Memoir 24.

Coleman.

Another area of Benton shale is found on a property tunneled by G. H. Bradley, about 2 miles southwest of Coleman, or about three-fourths of a mile west of the second bridge on the road from Coleman to what is known as the Volcanic ridge.

Like the Blairmore material described above, it is a black slaty shale, 40 to 50 feet thick, and while the outcrop is plainly visible for 50 feet, Mr. Bradley claims to have traced it for 600 feet distance. The strike is northwest and the dip about 25° southwest.

A sample of the material (Lab. No. 1885) was put through a series of physical tests.

As it is a very sandy shale, of poor plasticity, it took only 18 per cent of water to work it up. The air shrinkage was 3 per cent and average tensile strength 31 pounds per square inch. The shale burned to a greyish brown body, of not very good colour, and practically no fire shrinkage, up to cone 1. It is not a fireclay, for it was completely fused at cone 9. The body, however, after burning even at cone 010 was fairly hard, and the absorption from this cone up to cone 1 was 12 per cent.

This shale does not appear to me to be a satisfactory one to use alone. Its main use would be as a corrective for some other clay or shale. That is to say, it could be added to some clay or shale of high shrinkage to reduce the same. The carbonaceous character of the shale would also require it to be fired slowly until the carbon is burned off.

Sentinel.

Crowsnest lake is situated about 2 miles west of Coleman, the line of the railway skirting along the north shore of the lake. Sentinel mountain is on the south side of the lake.

In this area the massive sandstones of the Allison formation contain interbedded shales, some of which have been quarried for use in sewerpipe manufacture by the Alberta Clay Products Company of Medicine Hat.

On following the wagon road from Coleman to Sentinel, (Fig. 4) a little above the lake outlet there is a cut showing sandstone and some hard shale.

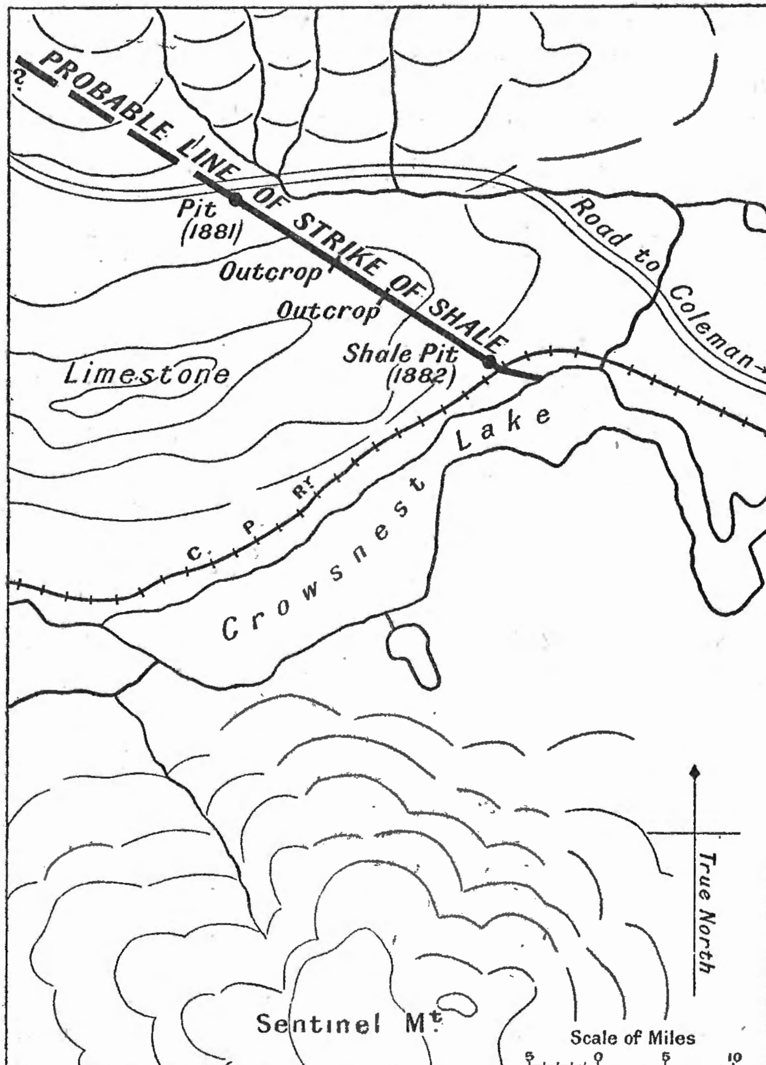


Fig. 4. Index showing location of shale deposit near Sentinel, Alberta.

The shale is said to have been used in the coke ovens at Coleman. Although the material (Lab. No. 1881) is sandy, it has a fair plasticity when ground up and mixed with water, and in drying showed an air shrinkage of 5·5 per cent. The average tensile strength was 80 pounds per square inch.

Several wet-moulded bricklets were burned with the following results:—

Cone.	Fire shrinkage.	Absorption.
010	1·1	10·40
05	3·1	5·60
03	3·3	4·1
1	5	3·1
5	Nearly fused	....

The shale burns to a red colour. It will also be noticed that it has a low fire shrinkage, and a low absorption from cone 05 on. While it no doubt works well as an ingredient of a sewer-pipe body, it would be well to mix with it some material that is somewhat more plastic and also a little more refractory. It could be used also for making brick.

The strike of the beds in this pit along the road is north 55° west, while the dip is southwest 35°-40°.

Along the railway track at the east end of Crowsnest lake a pit has been opened by the Alberta Clay Products Company (Plate IV). This shows at least 20 feet of shale, but the face of the excavation is only about 10 feet high and 50 feet long. The shale which dips about 35° S.W. is slickensided and broken for the rocks have been rather strongly folded. There are also thin streaks of sandstone in the shale, but the latter seems to be traceable in a northwest direction to at least as far as the wagon road, a distance of about 500 feet.

A sample (Lab. No. 1882) was taken from this pit, and put through a series of tests, as given below.

The material worked up with 19 per cent of water to a moderately plastic mass, whose average tensile strength was 70 pounds per square inch. The average air shrinkage was 5 per cent. The clay burned reddish brown, and gave a nearly steel

Shale pit at Sentinel, Alta.

hard body at cone 05, but is not vitrified at cone 1 as the following burning tests show:—

Cone.	Fire shrinkage.	Absorption.
010	·7	12·00
05	3·5	8·20
03	4·5	4·80
1	4·7	4·00
3	....	....
5	....	....

This clay could be used in brick manufacture. It could also be used as an ingredient of fireproofing and sewerpipe.

If we compare the tests of this one (1882) with the other one (1881) from the same locality, it wll be seen that there is not so much difference between the two, but the outcrop along the track gives a better exposure.

About 200 feet west of the pit, along the railway there is a small cut showing interbedded heavy sandstones and shales. The beds here are much steeper, having a dip of 60° west and striking almost due north.

In considering the shales from this Sentinel area, several important facts have to be considered.

(1) The amount available. It is quite evident that the shales do not form a large mass by themselves, but are interbedded with the sandstones. Consequently the area should be carefully prospected, in order to ascertain the amount of shale, and its distribution.

(2) Availability or the ease with which it can be extracted. If the shale lies flat, with little overburden, its extraction is simple. If it has a steep dip, and broad outcrop, it could be worked as an open-cut along the strike and to a certain depth, without having to strip off much worthless material. If it dips and is followed down the dip, then the item of stripping may soon become prohibitive.

(3) Quality. There is little doubt but that this material is about as good as anything that has thus far been tested from the Crowsnest Pass district, in fact it is better than the other samples tested.

(4) Up to the present time it has been hauled to Medicine Hat and used to mix with the Belly River shales from Coleridge, but the last named shale formation could be found nearer to the Crowsnest Pass district than Medicine Hat.

Crowsnest.

About one-half mile from the station, in township 8, section 11, range 6, west of the 5th, a series of shales are exposed in what appears to be one limb of a low anticline. This section is along the road to Summit. A sketch of this section is shown in Fig. 5.

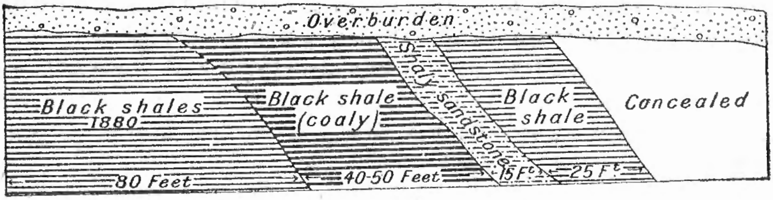


Fig. 5. Sketch section south of Summit station, Crowsnest pass.

The shales exposed are all carbonaceous, and the best one appears to be at the southern end of the section. It is, therefore, the lowest one of the series exposed, but it could be worked without the others having to be removed.

For this reason a sample (Lab. No. 1880) was tested in some detail with the results given below.

This is a sandy, granular shale, which worked up with 19·7 per cent of water to a mass of somewhat poor plasticity and had a tensile strength of 45 pounds per square inch. It was too sandy to work through a die, but could be moulded by wet-moulding and burned to a nice red colour. The average air shrinkage was 4 per cent.

Fire tests of the wet-moulded bricklets yielded the following results:—

Cone.	Fire shrinkage.	Absorption.
010	1·0	10·00
05	1·3	6·70
03	2·0	5·40
1	Slightly swelled	2·00

The clay burns to a good hard body even at 010, being even nearly steel hard at that cone. Its absorption is also low. It was nearly impervious at cone 1, but had swelled slightly, so that its vitrifying point is a little lower. However, there is no need of burning it up to this point in order to get a hard product.

A dry-press bricklet also gave good results. At cone 010 with 1·0 per cent fire shrinkage its absorption was 9·51 per cent, while at cone 05 with 1 per cent fire shrinkage the absorption was 7 per cent.

In view of the fact that this clay is rather low in its plasticity, it would probably be best to work it dry-press, instead of by any plastic process.

It is not refractory, so could not be used for firebrick, neither is it plastic enough to be worked for fireproofing or tile.

Michel.

No shales of satisfactory quality were found at the coal mines at Michel.

Hosmer.

The rocks at Hosmer are mainly shales and sandstones. Near by the main tunnel, along the gorge, the Fernie shales outcrop, but they are very sandy.

Fernie to Gateway.

A branch of the Great Northern railway runs from Fernie to Gateway, the latter being a station on the International Boundary. It is along this line that the so-called Elko fireclay occurs, and other clay occurrences have been reported at different points along the line. For this reason it was thought desirable to make a reconnaissance of the route to determine if any deposits worth testing and working might exist. The following data give a summarized statement of what was noted, it being stated by way of explanation, that the mile posts begin at the southern end of the route.

At mile 55 in track section 14, the rock cuts show gritty shales overlain by sandstone.

Between miles 50 and 51 there are small pockets of impure clay, which, however, are not worth working.

Sandstone is encountered at mile 49, and the same rock is found at intervals as far north as mile 44. About mile 49 are also cuts of sand and boulders.

At Elko, near the wagon bridge, the cliffs extend up stream at least one-fourth mile. These are quartzite with interbedded talc schist, the latter being as much as 4 feet 6 inches thick in places. The strike is almost due east and the dip 27° north. This talc schist has been erroneously called a fireclay, and although it has been emphatically stated in an earlier report that the material has no claim to this name, it continues to be advertised as such.

Near the government road bridge at Elko, there are some fair-sized pockets of yellowish brown clay, which contain considerable material. The possibilities of the clay as a brick material are set forth in the following tests.

The clay is plastic enough to work into brick, but its air shrinkage of 8 per cent is a little high, and some sand would have to be added to reduce it. The average tensile strength is high, viz., 200 pounds per square inch. The clay (Lab. No. 1887) burns to a red colour, and good hard body even at cone 010. It is vitrified at cone 3, and completely fused at cone 5.

The burning tests at other cones gave the following results:—

Cone.	Fire shrinkage.	Absorption.
010	·4	20·00
05	·6	18·40
1	·6	18·83
5	Fused	.....

The clay is to be graded as a good common brick or tile clay, which might be used by a small plant. But there is not enough to support a large industry.

Going on down the railway, sandstone cuts are encountered at mile 38, sand cuts near Baynes station, and a whitish, clayey sand between mile-posts 26 and 28.

There is shale south of mile 20, but it is a shaly sandstone correctly speaking, and hence not desirable for working into clay products.

About mile 15 there is a 10-foot bed of yellowish clay, but the overburden of sand and gravel is too heavy to make it worth working.

EDMONTON TO YELLOWHEAD PASS.

In the first report on the western provinces, the shales associated with the lignites around Edmonton were described, and it was pointed out that most of them would require preheating in order to prevent cracking during drying. The only shales worked were those near the Twin City mine on the south side of the river near Strathcona (now Edmonton South). These are still being worked.

Two samples from the Edmonton formation were sent in during the past winter by Prof. J. A. Allan of Edmonton. The exact location of them is not known, but in their properties they behave more like some of the Edmonton clays from near the Pembina river, than they do like those of the same formation around Edmonton.

Allan's sample No. 2 (Laboratory Number 1915) worked up easily to a plastic mass and although I am informed that it belongs to the Edmonton series, it really acts more like a surface clay. The clay has 6 per cent air shrinkage. At cone 010 it burned to a light red colour, with 1 per cent fire shrinkage and 15 per cent absorption. At cone 1 the fire shrinkage was 11 per cent and the absorption 5 per cent. Fused at cone 3-4.

The clay is probably plastic enough to work for fireproofing but the high fire shrinkage at cone 1 is against its use by itself. However, the next described sample could be mixed with it as a corrective, to reduce the high fire shrinkage. It should serve as a good brick material to be burned at the lower cones.

The other sample, marked No. 1 (Lab. No. 1914), is not quite as soft as the preceding clay, but nevertheless it breaks down to a very plastic mass, and had 5 per cent air shrinkage.

At cone 010 it has zero per cent fire shrinkage and 18 per cent absorption. At cone 1, the fire shrinkage was 3·6 per cent with 15·70 per cent absorption. The clay did not fuse until cone 5.

Unfortunately the samples sent were not large enough to test a mixture of these two clays. It seems to me, however, that the two together would work well for fireproofing, and possibly paving brick.

In the report for last year, reference was made to the shales along the Lobstick river near Entwistle, which presumably belong to the Edmonton series.

McEvoy in his report[1] gives several sections at the Pembina crossing, showing the occurrence of shale. He also refers to the heavy beds of sandstone at the top of the section, which he considers to belong to the Paskapoo formation, which overlies the Edmonton.

McEvoy gives a description of the geology of the route to the Yellowhead pass, and the following paragraphs with quotation marks, are from his report, while the other comments have been made by the writer of the present report.

"Four miles west of Pembina crossing in the bed of the first small tributary of the Lobstick river, loose slabs of yellowish sandstone are abundant, indicating the near presence of the Paskapoo beds. Beyond this nothing is seen but the surface deposit of yellowish-white sticky clay, until two miles east of Coldwater creek, where the northern end of a terrace-like ridge is crossed. The soil on this ridge is a coarse, brownish-yellow sand and seems to be locally derived from the Paskapoo sandstones that appear to underlie the greater part of the country between the Pembina and McLeod rivers."

If the Paskapoo extends all the way to the McLeod river it must be quite thin, and the Edmonton must lie close to the surface, for there is considerable shaly material exposed in the banks of Wolf creek. Moreover, McEvoy on his map seems to tentatively place the boundary of the Paskapoo east of Wolf creek. The yellowish-white, sticky clay which he refers to above is evidently a Pleistocene surface deposit, and might work for common brick, although it would probably be necessary to add sand to it.

[1]Can. Geol. Surv., XI Rept., Part D, 1900.

McEvoy continues: "White clay continues to a point midway between Wolf and Moose creeks, called the Sand Hills, where a long esker commences."

This white clay is probably surface clay which although whitish when unburned is very likely to burn to a coloured body.

"The eastern drift extends to within two miles of the Sand Hills, or about a mile west of Wolf creek. Beyond this point towards the west, no drift was seen, except that derived from the Rocky Mountains."

At Wolf creek, the river has cut a fairly deep gorge, in which beds of shale and shaly sandstone are exposed somewhat as indicated in the section, Fig. 6, which is taken from the west bank of the creek south of the bridge.

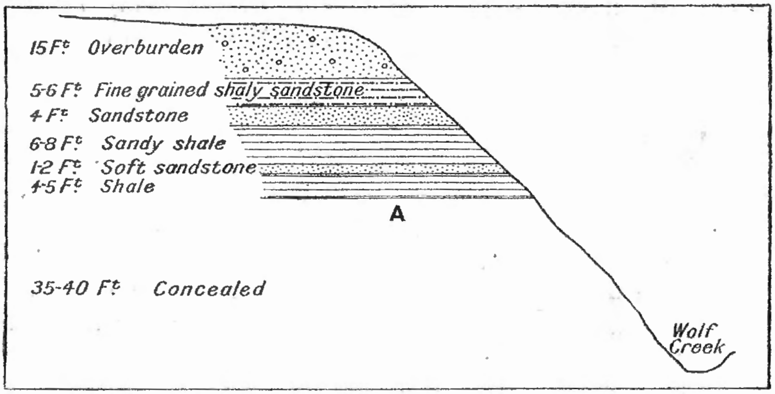


Fig. 6. Section on south side of bridge, on west bank of Wolf creek, Alberta.

Owing to the fact that the bank has slaked down considerably it was difficult to get a good clean sample. One was taken for testing from the bed marked A in the section, and the tests of this are given below.

These tests indicate that the material has a somewhat high air shrinkage, and also a high fire shrinkage, so that it could stand having some of the overlying material mixed in with it. Moreover, on the north side of the bridge the overlying sandy beds do not appear to be as heavy as on the south side of the bridge.

It will be noticed that the lower 35 or 45 feet of the section is concealed by wash, but I have been informed by the engineers who were in charge of the Grand Trunk Pacific bridge construction at this point, that much soft shale was penetrated in sinking the bridge foundations.

In testing this locality in more detail, reference to the conditions along the Pembina near Entwistle will be helpful. There it was found that on the higher ground the Paskapoo sandstone cap was heavy but on the lower ground most or much of it had been eroded away.

Another point to be considered is the removal of the overburden covering the shale deposits. If this is sandy or gravelly, it could be removed by hydraulicking as is done in some districts.

Further prospecting should be done in this area either by test pits or borings, for there is undoubtedly considerable shale there, and more thorough exploitation can probably develop other well located deposits, which are now concealed by soil or tree growth.

The tests of the Wolf Creek sample (Lab. No. 1860) are given below.

This shale worked up with 33 per cent of water to a mass of good plasticity, whose average air shrinkage was 8·5 per cent and average tensile strength when air dried 138 pounds per square inch. The air shrinkage is somewhat high, but it could be reduced by working in some of the more sandy layers contained in the bank. The clay burns to a rich deep red, and is steel hard and practically vitrified at cone 05.

The firing tests were as follows:—

Cone.	Fire shrinkage.	Absorption.
010	1·5	15·5
05	8·7	0
03	8·6	0
1	9·3	0
3	Nearly fused	....

These figures bring out the fact that the clay vitrifies at cone 05, and stays without much change up to cone 1.

I believe that if the air shrinkage were reduced, the shale would make a promising material for vitrified brick and fireproofing. Indeed it is somewhat similar to the Edmonton shales tested from near Entwistle.

No trouble was experienced in making the clay flow through a 3 inch die. The tile so made were burned at cone 1 and gave results similar to the bricklets. The clay can also be dry-pressed.

Quoting further from McEvoy, it is stated that: "Half a mile below the crossing of McLeod river, the following section was seen:—

	Feet	Inches
Yellowish silty sand	3	0
Coarse yellowish-grey sandstone	50	0
Grey friable clay-shale	2	0
Carbonaceous shale	0	6
Lignite	0	6
Soft grey sandstone, some clayey bands false bedded	30	0
	86	0

"The grey friable clay shale contains petrified wood and fossil plants. The beds are horizontal. There is nothing to be seen that would clearly show what is the age of these beds, but on account of their geographical position and the presence of soft clayey sandstones, they are doubtfully assigned to the Edmonton beds of the Laramie."

The section given above does not show very much shale.

McEvoy gives another one, which he states is on the east side of the McLeod river, 6 miles above the "Leavings," and whose estimated thickness he gives as follows:—

	Feet
Yellowish and grey sandstones with harder layers and nodules	20
Grey shale	5
Grey sandstone	8
Yellowish-grey clay shale	6
Yellowish-grey sandstone, nodular	10
Grey clayey sandstone with thin carbonaceous seams at top	7
	56

This shows considerably more shaly material, the main objection to it being the sandstone stripping.

McEvoy[1] gives a section of 279 feet on Sandstone creek, 2½ miles from its mouth, which shows a number of shale beds, but nothing is known regarding their physical characters.

Beyond Prairie creek one comes into the Rocky mountains, which here consist of strongly folded, and sometimes faulted stratified rocks, ranging from Devonian to Carboniferous in age, the upper Palæozoics extending westward to about Henry House, where the Cambrian sediments, likewise strongly folded, begin.[2]

Along the line of the Grand Trunk Pacific railway, from Prairie creek to and through the Yellowhead pass, there are a number of rock cuts, but in none of these was any indurated clay rock exposed that could be regarded as suitable for the manufacture of clay products. It is true that shaly beds occur, but they were, so far as observed, siliceous, hard, and at times more slaty than shaly.

One of the most promising areas in which to prospect for shales to be used in the manufacture of clay products is in the Jasper Park region. Here on the south side of the river several coal seams have been opened up, and associated with them, so far as known, are carbonaceous sandy shales, which do not appear very promising, but the section cannot be said to have been fully explored, so that other shales in these Cretaceous beds may be developed later.

Some test-pitting has also been done in the steeply dipping beds on the north side of the river, and at one point a bed of very plastic shale was found associated with the coal seam. This shale (Lab. No. 1859) was about 6 feet thick and of a calcareous nature, as could be told from the strong effervescence which it gave with hydrochloric acid.

It worked up with 24 per cent of water to a moderately plastic mass, whose average air shrinkage was 4 per cent and average tensile strength 66 pounds per square inch. The clay burns to a buff brick at cone 1. At cone 010 its fire shrinkage was 0, and absorption 21·70 per cent. At cone 05, the fire

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[1] l.c., p. 26 D.

[2] See McEvoy's report, l.c., and Dowling, Can. Geol. Surv., Summary report for 1910, p. 150, 1911.

shrinkage was 0·6 per cent and absorption 20·50 per cent. At cone 1 the fire shrinkage was only 1·7 per cent, absorption 15·10 per cent, and the bricklet nearly steel hard. It fused at cone 4.

The clay burns to a good cream colour, but would have to be worked in conjunction with the coal bed; still if the latter was mined there would be little difficulty probably in taking out the shale. As the ground on this side of the river has not yet been opened very much, further exploring may uncover other clays of value.

At Pocahontas, on the south side of the river where the collieries are located, the coal company in driving a tunnel from near the railway level to strike one of the coal seams passed through a deposit of dark coloured, tough, plastic clay, which is evidently part of a recent lake deposit, such as Dowling[1] states has been found in this region. Whether additional deposits of this character have escaped erosion is not known, and the one in question is not exposed at the surface, but is covered by wash.

On account of the location of the deposit, which is situated near the surface along the line of the tunnel, a test was made of it, with the following results.

The clay (Lab. No. 1858) required 26 per cent of water for mixing, and had an air shrinkage of 7 per cent. The average tensile strength was 105 pounds per square inch. A full-sized brick of the clay dried without cracking provided the drying was not pushed.

The following burning tests were obtained with the wet-moulded bricklets:—

Cone.	Fire shrinkage.	Absorption.
010	1	25·10
05	1	24·80
03	1	24·80
1	1·9	25·00
4–5	Fused	....

[1] l. c., p. 155.

These tests show a behaviour in burning which is characteristic of a highly calcareous clay. Moreover, the cream colour when burned is also characteristic.

In addition to moulding the clay wet, it was also moulded dry-press, and the bricklets so formed burned at several cones.

At cone 010, the bricklet had an absorption of 27·9 per cent; the colour was cream pink, but the product was not hard enough. At cone 05 the colour was creamy white, absorption 28·40 per cent, and the brick had a fair ring although not steel hard. At cone 1 the colour was a nice cream, absorption 23 per cent, and fire shrinkage 1·3 per cent.

It seems from these tests that while the clay can be moulded dry-press, still the body is too porous after firing, and it would be best to mould it by one of the plastic methods.

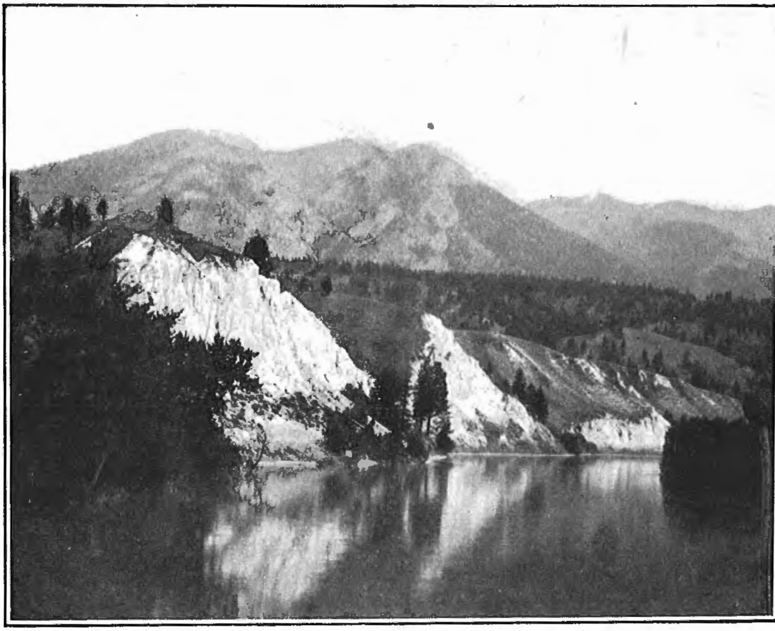
The clay was further tested by running it through an annular die, in which it worked very nicely, flowing smoothly and without cracking so that tile could be formed from it. These were fired at cone 1, with similar results to those obtained by burning the bricklets at the same cone.

The calcareous nature of the clay, which is the cause of its cream-burning qualities, is also brought out by the following analysis:—

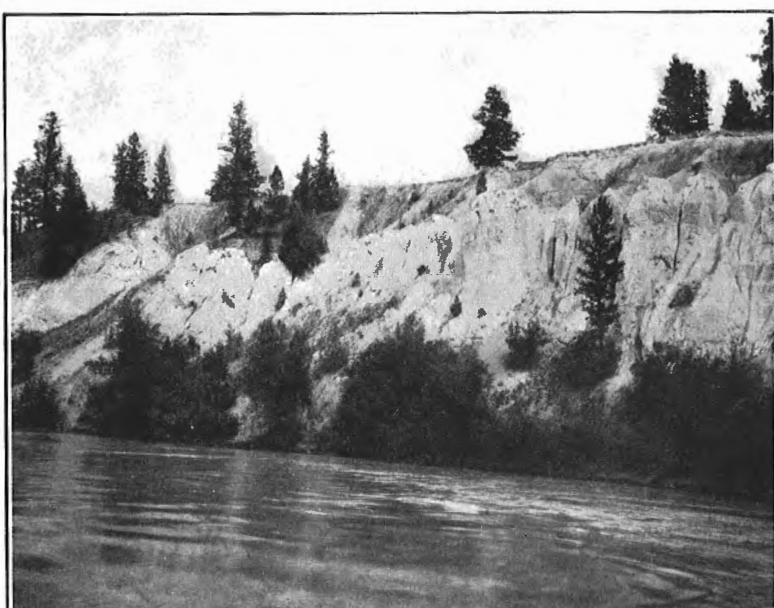
Silica (SiO_2)	40·07
Alumina (Al_2O_3)	12·11
Ferric oxide (Fe_2O_3)	4·80
Titanic oxide TiO_2	0·50
Lime (CaO)	15·54
Magnesia (MgO)	2·60
Alkalies (Na_2O, K_2O)	4·38
Loss on ignition (H_2O and CO_2)	18·95

Even though the material is strongly calcareous, it showed no lime pebbles, which is an advantage, and the lime carbonate is, therefore, evenly distributed through the material.

It forms a good material for making cream-coloured brick, that can be used for ordinary structural work, and also facing.



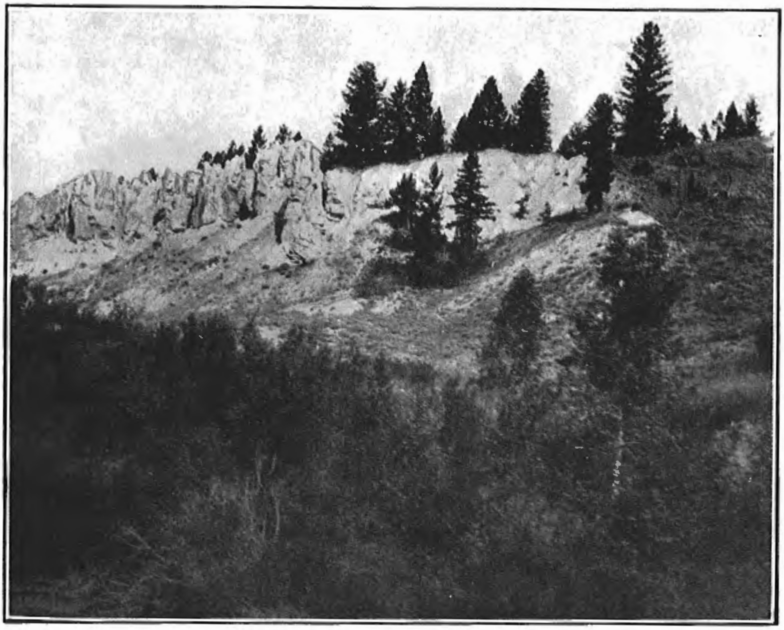
A



B

A. Silt bluffs along Columbia river, north of Lake Windermere, B.C.

B. Cut bank in bend of Columbia river, near Athelmere, B.C. The calcareous silt deposit shows characteristic steep faces.

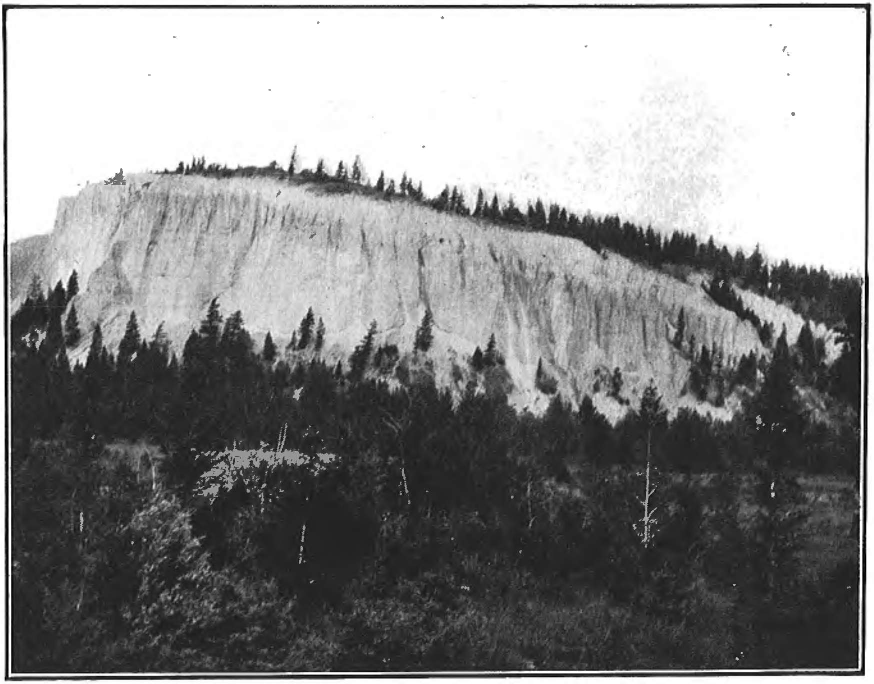


A

B

A. Erosion forms ("Hoodoos") in silt clay formation along Columbia river, north of Lake Windermere.

B. Lake Windermere, B.C. The long line of silt bluffs is seen bordering the lake shore.



Bluff of silt and gravel, overlooking flat between Lake Windermere and Upper Columbia lake.

West of Jasper Park, there are probably no extensive shale formations, at least not east of Tete Jaune Cache.

There is always the possibility of finding deposits of lake clays or boulder clays, which are suitable for common brick, and occur in sufficient quantity to support a small brick plant. None of any extent were observed east of Grand Forks, but some small deposits of stratified clay were noticed along Moose lake between miles 28 and 29. I am also informed by Mr. Heamon of the Grand Trunk Pacific Engineering Department, that some rather large deposits were found at several points along the Fraser river between Fort George and Lytton.

COLUMBIA AND KOOTENAY VALLEY SILTS.

The Columbia river from Golden to Lake Windermere, occupies a large valley which separates the Rocky mountains from the Selkirk range. Lakes Windermere and Columbia lake are really an expansion of its upper course, since the river heads in the swampy tract known as Canal Flats, where the Columbia valley joins that in which the Kootenay river flows. The latter river then continues southward to Fort Steele, where it is joined by the St. Mary river flowing in from the west.

The peculiarly interesting economic feature about this region is the wide-spread deposit of silty clay which follows the valleys of the rivers mentioned above. Reference was made in last year's report to the flood-plain clays at Golden in the Columbia valley, which are quite calcareous in their nature. These were found only little above the river level.

If we follow southward up the river, when a point about half way between Spillimacheen and Athalmer is reached, one begins to note bluffs of a yellowish silty clay (Plates VIA and B and VIIA) which often rise steeply from the river level, especially where the stream has formed cut banks. Rain and weather sometimes carve this clay formation into fantastic shapes known as "hoodoos" (Plate VIIA).

The formation is then traceable along both sides of Windermere lake (Plate VIIB), where the light-coloured silt bluffs stand out in great prominence in the sunlight. There the formation underlies terraces which rise to a height of at least 100 feet above the lake level.

The deposit also forms great bluffs in the flat land between Windermere and Columbia lakes, but is not so prominent along the latter as the former.

Following down the Kootenay valley the silts are prominent again at Wasa, while around Fort Steele they form high bluffs bordering the valley. Similar clay is also found in the valley near Cranbrook.

In its typical form this material is a fine grained, porous silt. Here and there, the clay contains streaks or layers of sand and gravel, and in places, as in the bluffs south of Windermere lake and in some of the bluffs around Fort Steele, it is very gravelly. Where the gravelly streaks are present, they seem to be often of lenticular character. In consequence of this, one can find at the same level, in passing from point to point, first clay, then sandy gravel, and then again clay. This variation can be well seen at Fort Steele in following the railway track northward from the wagon bridge, around the base of the bluff.

The possible use of this vast silt deposit is an interesting and perplexing problem, and the utilization of that in the Columbia valley would be of importance, since there will shortly be a railway in operation from Golden to Fort Steele.

The silt was examined at a number of points, and several samples were taken for testing, the first sample taken being from the bluffs at Athalmer (Lab. No. 1876).

This is an exceedingly silty, calcareous clay, of very low plasticity. It was practically impossible to form it satisfactorily in a plastic condition, and consequently some samples of it were moulded dry-press.

The shrinkage of these was practically zero, in fact they swelled slightly. The absorption after burning was also high, being 42 per cent at cones 010, 05, 03, and 1. The clay was not carried beyond this, but it probably behaves similar to that from Fort Steele.

Other samples tested from farther up Lake Windermere behaved in the same manner.

The next sample tried (Lab. No. 1889) was from the bluff at Fort Steele.

This silty clay, which is similar to that found along Lake Windermere, gave a mass of very low plasticity but still sufficiently pasty so that it could be moulded. It soaked up 24 per cent of water in mixing, had an average air shrinkage of 1·3 per cent and an average tensile strength of 40 pounds per square inch. The clay burned to a buff-coloured, very porous body, with no fire shrinkage up to cone 3; in fact it even swelled slightly at 010 and 03. The absorption at cone 010 was 31 per cent; at cone 05, 30·5 per cent; at cone 03, 30·90 per cent; and at cone 1, 32 per cent. At cone 7 the body was hard but still porous, and at cone 9 it had melted to a glass. It, therefore, softens very rapidly as highly calcareous clays do.

This clay, abundant as it is, does not seem to be worth making common brick of, neither is it a fireclay.

To sum up the properties of these clays, it may be said that they are very silty, have a low air and fire shrinkage, burn to a very porous product, and are not refractory. They are, moreover, difficult to mould, even though it is true that a small brick plant has been utilizing them at Invermere. At this place, however, the silt carries a little more clay than usual.

There are only two possible uses that suggest themselves.

One is to make porous partition blocks, but to do this it would be necessary to add some plastic clay as a bond. Assuming this is practicable, there remains the difficulty of finding a market. A second possible use is for scouring brick, such as are made near Bridgewater, Eng. There the product is made from a calcareous tidal silt, which is moulded into bricks and burned just hard enough to make the grains bind together, but not enough to prevent their being scraped loose for cleansing purposes. Some of the bricklets were given a trial with good results.

In the valley near Cranbrook there is a silty clay which looks much like the Columbia Valley silts, but is somewhat more plastic. It is of light yellowish colour and sticky when wet. Indeed it is considerably more plastic than the Columbia Valley silt, although it looks and feels much like it.

The following section, Fig. 7, shows the structure of the clay bank from which the brick material is taken.

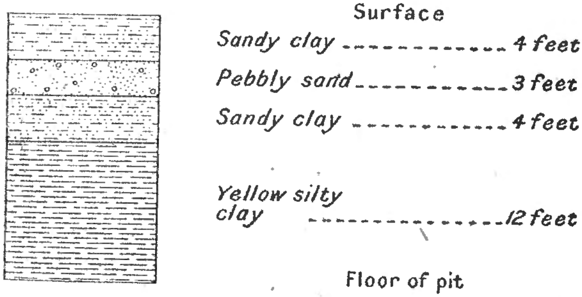


Fig. 7. Section in clay pit of brick works near Cranbrook, B.C.

In making bricks the run of the bank has been used exclusive of the pebble layers.

The clay is put through rolls, pugmill, and stiff-mud machine. Drying is done on pallet racks, and burning in scove kilns. The clay burns red.

COLUMBIA RIVER NORTH OF REVELSTOKE.

There exists a common impression that deposits of surface clay are not to be looked for in the mountain region, but this is not altogether correct, for here and there in protected spots, one often finds not only pockets or masses of boulder clay, but also remains of lake-clay deposits which have been deposited in the valleys.

In the central part of the mountain region there are a number of growing towns, which demand brick for building purposes, and at present time have to haul them a considerable distance. Along the main line of the Canadian Pacific railway there is no common brick plant between Cochrane and Kamloops. In southern British Columbia there is a small dry-pressed brick plant at Blairmore, and a smaller common brick plant at Nelson. Hence it seems there is room for development. Revelstoke for example has to haul bricks a long way.

In view of these facts, and also because a line of the Canadian Northern railway has been surveyed down the Columbia River valley to Revelstoke, it seems desirable to ascertain the clay possibilities in the valley mentioned.

The river valley was accordingly followed as far as Downing creek about 45 miles from Revelstoke. Although the valley is narrow, and the sides heavily wooded, I found banks of clay at several points. Below Ford river, a tributary, the banks of surface material were mostly sandy and gravelly, but above this point, several high banks of plastic, sandy, laminated clay were exposed, one of the highest being just below Ford river, where there is also room for a small plant.

One of these banks was sampled from top to bottom and the mixture so obtained put through a series of physical tests.

This clay (Lab. No. 1877) is quite plastic, even though it contains considerable fine sand and scattered mica scales. It flowed smoothly through an annular die, but cracked if dried very rapidly, although not as badly as some of the samples tested. The average air shrinkage was 6 per cent and the average tensile strength 110 pounds per square inch.

Samples of the clay were wet-moulded and dry-pressed, the results of the firing tests on these being as follows:—

Wet-moulded Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	0	19·20
05	2·3	13·20
03	5·0	9·30
1	7·7	4·70
3	Deformed	....
4	Viscous	....

The clay burns to a reddish-brown colour and was steel hard at cone 05, but still even at cone 010 it gave a hard body with a good ring, suitable for brick manufacture. The material could, I believe, also be used in the manufacture of drain tile.

Dry-press Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	1	20·60
05	2	18·50
1	5	10·80

The dry-press bricklets had a good colour, but should be burned to at least cone 05 to obtain a body of sufficient hardness.

MISCELLANEOUS LOCALITIES IN SOUTHERN BRITISH COLUMBIA.

As evidence of the fact that deposits of surface clay are widely scattered through the mountains, one hears continually of new ones each time that a visit is made to this region. It has not always been possible, however, to investigate all of them, and many of them, moreover, are so located that at the present time they are not sufficiently accessible by rail to warrant their being worked. Among those to which our attention was called this last summer, was a deposit of clay on the land of John Carrigan, on Sixmile creek, 6 miles north of Fort Steele.

This clay (Lab. No. 1872) is slightly calcareous, but not sufficiently so to give a cream coloured brick.

It is very sticky and plastic, but flows smoothly through an annular die. Its average air shrinkage is 4·6 per cent but it has to be dried slowly to prevent cracking. The average tensile strength is 154 pounds per square inch. The clay is somewhat calcareous but not sufficiently so to give a cream coloured brick.

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

Cone.	Fire shrinkage.	Absorption.
010	1·6	14·6
05	8	5·6
03	8	1·3
1	7·3	0·0
4	Fused	....

The clay makes a good common brick body of light red colour at cone 010, and is steel hard but not much deeper in colour at 05. It could probably be moulded dry-press, and could also be utilized in the manufacture of drain tile. Some persons have called this a fireclay, but it is not refractory.

D. A. McFarland of the Dominion Development Company, Ltd., at Nakusp, claims there is a deposit of blue clay 1½ miles south of Nakusp. This is perfectly possible, as bluish clays are to be seen close to the water level at a number of points along the Arrow lakes.

In the railway cuts near Creston, much yellowish laminated loamy clay is also exposed.

PRINCETON DISTRICT.

The coal formation of the Princeton basin covers an area of about 50 square miles, according to Camsell. At Granite creek the coal basin, according to the same author, covers about 8 square miles[1].

As outlined by the same author in the Summary Report for 1909, the rocks are of Oligocene age, and consist of sandstone, shale, conglomerate, and beds of coal, but no systematic investigation of the shales has been undertaken.

Two years ago a sample was tested from Collins gulch,[2] but this is the only one examined.

During the summer of 1912 my assistant, E. D. Elston, collected some samples from the mine of the Columbia Coal and Coke Company at Coalmont, which showed some rather interesting contrasts.

The coal is said to lie in a basin with coal partings which average a little over 1 foot in thickness. The floor of the coal is usually a softer shale than the roof.

One sample was collected about 2000 feet from the entrance of the main tunnel.

This shale (Lab. No. 1890) worked up to a very plastic material, but had specks of lime, which caused it to disintegrate if not burned hard enough. It worked up with 29 per cent of water to a mass which flowed smoothly through an annular die. The average air shrinkage was 8·3 per cent and the average tensile strength 150 pounds per square inch. The clay burns to a brownish red colour.

The high air shrinkage is somewhat of an objection, but more serious is its calcareous nature, for it contains small lumps of carbonate of lime. When burned to cone 010 and allowed to

[1] Jour. Can. Min. Inst., Vol. XIV, p. 609, 1912.
[2] Memoir 24, p. 116.

stand in the air, the brick crumbled after a few days. In making brick from it, therefore, it should be thoroughly ground and mixed, and burned to not less than cone 05. At cone 010 the fire shrinkage was 1·4 and the absorption 18·00%.

A dry-press bricklet was also tried but did not give a good product under cone 05.

If properly handled the clay could be used for brick and tile, but it should be well ground, slowly dried to prevent cracking, and well burned. I do not recommend its use for pressed brick as the colour after burning is not good enough.

In the same mine there is another bed of soft shale (Lab. No. 1897), which has been noticed by the miners chiefly on account of its objectionable character, for when wet it showed a decided tendency to swell and disturb the timbering. A sample of this was sent to us, in order to ascertain the cause of the swelling. When we came to make some other tests on it, the material turned out to be of great interest on account of its refractoriness, because, up to date, it is the most refractory clay that I have found between Sumas mountain near Vancouver, and the Dirt hills of Saskatchewan.

The clay is strongly coloured by organic matter, and is exceedingly plastic, but it has a high air shrinkage, viz., 11·8 per cent, so that it has to be dried slowly to prevent cracking. It also cracks in burning, and warps, but burns to a hard, cream coloured body at cone 010. The fire shrinkage at 010 is under 1 per cent and the absorption 2·5 per cent. At cone 05 and at cone 1 the absorption was zero. The clay is vitrified but not yet viscous at cone 20.

The analysis given below indictates its refractory character:—

SiO_2	56·33
Al_2O_3	28·36
Fe_2O_3	1·37
CaO	1·60
MgO	0·73
TiO_2	0·40
Alkalies	2·00
H_2O	9·56
	100·55

The main drawback to the use of this clay is its cracking and warping, but this could probably be overcome by calcining a portion of it, before making up the brick mixture, and if it is to be used for firebrick, the market price of these would warrant the extra expense.

At Princeton, a curious rock is exposed in the bank of the Tulameen river, and known locally as fireclay. The material is greyish white in colour, very fine grained, brittle, and has a conchoidal fracture. In texture it resembles flint clay, but is not like it in lustre. The occurrence is shown in Fig. 8.

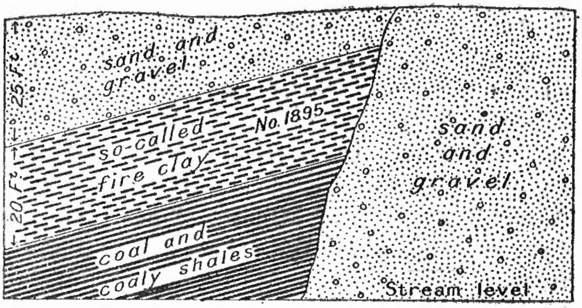


Fig. 8. Section by bridge across Tulameen river, Princeton, B.C.

A sample was ground up and mixed with water, but the material (Lab. No. 1895) had barely enough plasticity to stick together. However, we succeeded in moulding it into bricklets, which showed a very low air shrinkage of 0·6 per cent as might be expected.

Several bricklets were burned to see how it did behave in firing, and gave the results tabulated below:—

Cone.	Fire shrinkage.	Absorption.
010	2·4	32·50
03	13·6	5·10
1	15·7	·70

The clay does not appear to have any special use on account of its high sandiness, but there are enough fluxing impurities to bond the sand grains together into a hard body.

Some reddish sandy shales which outcrop on the road to Coalmont were also tried, but the material (Lab. No. 1893) is very sandy, and possesses very little plasticity. It moulded with difficulty and gave a bricklet at cone 010 that was too porous and soft to be of any use.

LOWER FRASER RIVER.

Two years ago, some attention was given to the laminated clays which are found along the Fraser river around New Westminster and other localities east of Silverdale. Some of these have been worked for common brick, and even tile for some years, and give a very good product. Tests of the brick made at New Westminster were also included in a former report[1] and gave excellent results.

The industry along the river has been quite progressive and was described by M. Carmichael in the annual report of the British Columbia Minister of Mines[2]. Since then several new plants have been established, and others will no doubt be added in the future.

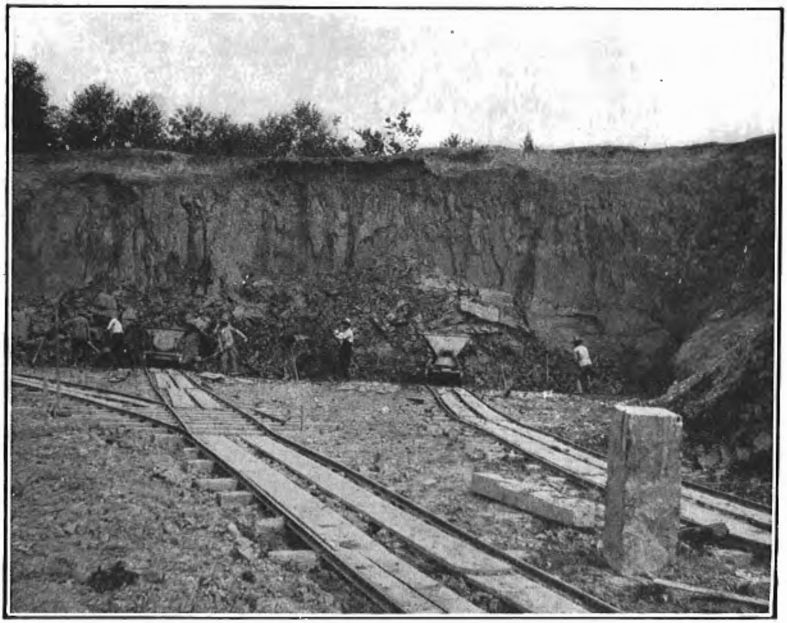
Some of these clays, although they appear hard and rather dry when dug, nevertheless contain considerable moisture, so that after working them for a short time without adding any water, they become soft and plastic enough to mould.

The two largest plants in operation in the Fraser valley are Coughlan and Sons at New Westminster, whose plant was described in an earlier report,[3] and the Port Haney Brick Co., at Port Haney. The clay which this plant is using (Plate IX) is less strongly laminated than that which is worked at the other yards. It has been employed for making common brick and drain tile, but fireproofing and partition tile have recently been added to the products from this plant.

The clay, and brickbats for grog, are ground in a wet pan, and the brick tile and fireproofing are all formed on stiff-mud machine. Drying is done in 120-foot tunnels, requiring 72 hours. The burning is carried out in circular downdraft kiln.

[1]Memoir 24.
[2]Report for 1908.
[3]Can. Geol. Surv., Memoir 24, p. 140.

PLATE IX.



Pit of Port Haney Brick Company, Port Haney, B.C.

A new brick plant has also been put in operation at Ruskin, known as the Heap Brick Company, Ltd. At the time of visit in the summer of 1912, they had installed a pug mill and stiff-mud machine. The clay was to be ground by means of a disintegrator and rolls. Drying was to be done in eight tunnels, warmed by radiated heat, and using mill refuse to produce the same. The Company planned to build a continuous kiln heated with oil fuel.

The clay bank has 5 to 8 feet of grey clay in the upper part and below this blue clay.

The clay from this locality (Lab. No. 1891) is a fairly plastic one. It worked up with 31·8 per cent of water, had an average air shrinkage of 6·6 per cent and an average tensile strength of 138 pounds per square inch. It flowed smoothly through an annular die, and dried pretty well, although full-sized bricks, when rapidly dried, checked slightly. The clay burned to a good reddish colour, and good hard body even at cone 010. It will also make a good dry-pressed brick.

The fire tests were as below:—

Wet-moulded Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	1·7	21·70
05	3·0	15·20
03	6·0	12·50
1	9·6	4·90
3	Nearly fused	....

This shows low fire shrinkage and moderate absorption up to cone 05.

Dry-press Bricklets.

Cone.	Fire shrinkage.	Absorption.
010	2	18·30
1	9	6·70

This is what might be termed a good all-round clay. It is adapted for common brick, dry-pressed brick, and drain tile.

On the south side of the Fraser river, opposite Silverdale (a station on the Canadian Pacific railway), the new line of the Canadian Northern railway skirts several cut banks of the laminated grey clays which could be utilized for the same purposes as similar clays now being worked along the river. The deposit is favourably located for working and for shipment either by rail or water.

A sample of the material (Lab. No. 1901) representing the run of the bank was collected for testing, and found to work up to a very plastic mass with an average air shrinkage of 7 per cent, but in practice this would probably be less. The average tensile strength was 183 pounds per square inch. It burned to a reddish brown colour, and gave a good body even at cone 010.

When wet-moulded, the following results were obtained:—

Cone.	Fire shrinkage.	Absorption.
010	0	16·20
05	·3	15·50
1	1·6	12·40
3	Nearly fused	.....

These show the clay to have a low fire shrinkage, and moderate absorption, as is desirable for common brick manufacture. The material can also be made into a dry-press brick, and might even work for drain tile.

VANCOUVER ISLAND.

The shales of the Northumberland formation have been referred to in two earlier reports,[1] and their rather hard and sandy nature has been emphasized. In places they consist almost entirely of hard shale, and again, at others, of siliceous shale interstratified with thin layers of sandstone. They are

[1]Memoirs 24 and 25.

sometimes slightly weathered to a depth of several feet, and this change serves to considerably improve their plasticity.

They are practically all red and brown burning, have a low fire shrinkage, and are not refractory. The most refractory one seen is a limited bed on Mayne island, which fuses a little above cone 9.

During the last few years, these shale deposits have been sought by not a few persons or companies desirous of embarking in the brick-making business, and plants have been established on Pender and Gabriola islands, as well as on Vancouver island near Nanaimo.

Since numerous inquiries have been addressed to the Geological Survey office regarding these shales, and several have been tested in connexion with the Survey work, it may be safe to make a few general statements regarding them.

These shales when fresh are hard and dense, and when weathered as they sometimes are to a slight degree and to the depth of a few feet, the weathering is mainly along the joint and stratification planes, leaving the core of the irregular blocks bounded by these planes still rather hard and fresh.

Grinding in the ordinary dry pan makes the material sufficiently fine to have a little but not enough plasticity when mixed with water. In order, therefore, to develop sufficient plasticity for wet-moulding, the material should be ground in a disintegrator after receiving a preliminary grinding in a crusher or dry pan. If the latter is employed, the shale can be screened before it passes to the disintegrator, so as to eliminate particles that are already fine enough.

It is possible to put some of these shales at least through a stiff-mud machine, provided the die has the proper taper, and the rate of flow through the die is properly regulated and the proper lubricant used. Each shale will probably present a separate problem in this respect.

The shales can in some cases at least be moulded dry-press.

The burning must be carefully done, as the shales, in some cases after reaching a certain point, become very dark in colour, without shrinking much more.

In conclusion, the situation is that these shales can be utilized if properly handled, but considerable experimenting may be necessary in each case, to discover exactly what the correct working conditions are. Moreover, I believe that if a little plastic surface clay were mixed with these shales their working qualities would be improved.

The writer does not wish to make an unfavourable comparison, but it seems to him that the surface clays found along the Fraser river at many points between New Westminster and Silverdale are easier materials to work than the shales of the Northumberland series.

Three brick plants were running on Nanaimo shales in the summer of 1912.

Gabriola Island. The Dominion Shale, Brick, and Sewer Pipe Company had a new plant on Gabriola island, at a point near the "False Narrows" and about 8 miles from Nanaimo.

In following down the west coast of the island from Nanaimo, the outcropping rock is chiefly sandstone, until a point near the brickyard, where shale begins to appear.

The section at the pit (Plate X) showed:—

Overburden	3	feet.
Shale	6–8	"
Sandstone	1½	"
Shale	4–5	"

The beds dip to the eastward.

The shale is bluish black or brownish black, and a sample of it (Lab. No. 1898) had the following physical properties.

When ground up and mixed with 19 per cent of water, it gave a mass of very fair plasticity with an average air shrinkage of 5 per cent and an average tensile strength of 50 pounds per square inch. It burned to a good, hard, red body when wet-moulded, and with care might be worked in a stiff-mud machine if, at least, some weathered shale is used in the mixture. The wet-moulded bricklets were tested with the following results.

Cone.	Fire shrinkage.	Absorption.
010	2·8	14·40
05	6	3·89
1	8·7	1·00
3	10·5	0
5	Fused	....

PLATE X.

Shale pit of Dominion Brick and Tile Company, Gabriola island.

A

B

A. Shale quarry, Pender island, B.C.
B. Brick plant, Pender island, B.C.

The clay burns to a very good body, with moderate fire shrinkage, and low absorption. If the deposit continues as plastic as this it should be capable of making a good hard brick. It can also be dry-pressed.

In the summer of 1912 the plant was equipped with a dry pan, stationary piano wire screen, four mould dry-press, four scove kilns, and one permanent kiln. The No. 1 brick were of a red colour.

Pender Island. The Coast Shale Brick Company had a plant in operation here, using a rather hard, gritty shale (Lab. No. 1879), which had the properties outlined below.

The material when ground pretty fine gave a mass of moderate plasticity. Indeed in practice it is found that a disintegration is necessary to treat it, as a dry pan does not comminute it sufficiently. In spite of its low plasticity it has a tensile strength of 90 pounds per square inch. The average air shrinkage was 3·8 per cent. It burned to a reddish-brown brick which became deep coloured at cone 1. It was nearly steel hard at cone 05.

The fire tests gave:—

Cone.	Fire shrinkage.	Absorption.
010	·80	14·70
05	1·7	11·50
03	2	4·4
1	5	1·0
3	Fused	....

The shale can be moulded into a hard brick with care, but it is not sufficiently plastic to use for fireproofing or tile.

In working this material the shale is first crushed in a dry pan, and then fed on to a Newaygo screen. The overs from the screen and dry pan go to a Williams disintegrator.

The tempering was being done in a pugmill and the moulding in a stiff-mud, end-cut machine. In the summer of 1912 the bricks were burned in scove kilns with oil fuel, but a continuous kiln was under construction at the time.

East Wellington. The shales are being worked at East Wellington, about 4 miles from Nanaimo, by the Mountain

Brick and Tile Co. The shale used (Lab. No. 1878) is somewhat hard and received a preliminary but insufficient grinding in rolls. Moulding was being done in a side-cut stiff-mud machine, drying on pallets and burning in scove kilns.

The weathering does not extend very deep at this point.

In making the laboratory tests of this material the shale was crushed sufficiently fine to pass a 20 mesh sieve. Even so it was not highly plastic, although thorough working improved its plasticity somewhat. It would not flow through the annular die, but with care could be forced through a rectangular one, and it could probably be moulded on a stiff-mud machine if a die of proper character be employed, and the material ground sufficiently fine. The clay had an average tensile strength of 70 pounds per square inch, and an average air shrinkage of 4·6 per cent.

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

Cone.	Fire shrinkage.	Absorption.
010	·4	12·00
05	1·4	8·75
03	3·00	5·50
1	2·4	4·00

The shale burned to a red brick, and gave a fairly hard body even at cone 010. The body was practically steel hard at cone 05. At cone 1 it was not impervious, but had softened so that it bore but little weight.

The conclusions are that the shale could be used for making common brick and possibly pressed brick, but in any event the material needs careful manipulation.

These deposits mentioned represent the only ones being worked in 1912.

Newcastle District. In addition to these there has also been tested in the laboratory a shale that is said to come from lots 2 and 26, Newcastle district, Union bay, Vancouver island.

The writer has not seen the locality from which the sample came, but judging from the colour of the rock it may represent partly weathered material. If so, it is likely to become harder as the deposit is penetrated deeper.

This shale (Lab. No. 1866) which was supplied by Mr. C. S. Meek of Vancouver, worked up with 21 per cent of water to a slightly plastic mass. Thorough kneading improved the plasticity somewhat. With care the material could, I believe, be run through a stiff-mud die. The average air shrinkage was 4·3 per cent and the average tensile strength 65 pounds per square inch.

The clay when wet-moulded burns to a reddish-brown brick, of good ring, and moderate absorption, as shown by the following firing tests:—

Cone.	Fire shrinkage.	Absorption.
010	·3	15·9
05	4·4	10·0
03	4·6	4·7
1	6·3	2·90
3	5·7	0

From these tests it will be seen that the clay is beyond vitrification at cone 3. It fused at cone 4.

The clay was also moulded into dry-press bricklets. These burned to a good red colour, but did not give a good hard body even at cone 05, and would have to be burned to cone 1. However, while the dry-press bricks were not hard at the cones mentioned, their absorption was low for this type of product, for at cone 010 it was 15·20 per cent and at cone 05 it was 12·50 per cent.

GRAHAM ISLAND.

Considerable activity has been shown on Graham island in recent months, in searching for coal, but the possibility of clays or shales occurring there has apparently not been considered. This is not to be wondered at, since, owing to the location of this island, their value would hardly be considered.

During the summer of 1912, C. H. Clapp of the Geological Survey, while on Graham island, collected two samples of shale which were sent to the writer for testing.

One of these, numbered 1211 by Clapp, was a greyish, rather soft shale. The other, numbered 1212, was a black slaty shale that was of no value by itself.

It was thought desirable to test the former by itself, and also in a mixture consisting of equal parts of the two.

The mixture of the two (Lab. No. 1906) worked up with 18 per cent of water to a mass of good plasticity, and 4 per cent average air shrinkage. The tensile strength was 50 pounds per square inch, which is not high. The clay burns to a deep buff colour.

No trouble was experienced in making wet-moulded bricklets from it, and these on burning gave the following results:—

Cone.	Fire shrinkage.	Absorption.
010	0	14·00
05	0	13·10
1	1·6	11·30
5	3	9·00
9	Unaffected	....
20	Nearly fused	....

The clay, while not viscous at cone 18, was somewhat softened.

It is certainly refractory enough to be used for making boiler brick or firebrick which will not be subjected to both intense heat and load.

I believe that this mixture could also be employed for face brick. It is too refractory to be used for common brick.

Lab. No. 1907. This is a greyish, somewhat soft shale, of fair plasticity, having an air shrinkage of 5·6 per cent and an average tensile strength of 60 pounds per square inch.

It burned to a pinkish body which was nearly stee hard at cone 05. At cone 05 the fire shrinkage was zero, and absorption 11·2 per cent. At cone 1 the fire shrinkage was 1·3 per cent and absorption 10·60 per cent. At cone 9 the fire shrinkage was 3 per cent and absorption 7·80 per cent but the bricklet was still unaffected. It does not fuse until cone 18.

This clay could be used for boiler setting brick and also face brick. It is probably plastic enough to be run through a stiff-mud machine.

Mr. Clapp informs me that deposits of glacial clay, suitable for brick making, are very common on Graham island.

PRINCE RUPERT REGION.

In view of the future importance of this town, as the western terminus of the Grand Trunk Pacific railway, it is not improbable that there will be considerable demand for bricks to be used in structural work. At present the nearest brick plants are at Vancouver, over 500 miles distant, which would mean a rather long water haul.

The country rock around Prince Rupert does not contain any shale rocks that could be employed for brick making, but there are a number of deposits of glacial clay, well located, which could be drawn upon. Thus reference has already been made to those on Graham island. Another large deposit is located on Porcher island, and the writer has been informed that several other islands nearby contain clays of this character. In addition a deposit is known to occur about mile 81 on the Grand Trunk Pacific railway.

Some idea of the general characters of these glacial clays can be obtained from the following tests made on a sample collected from near Prince Rupert. Like many others of its type, it is very plastic, even though quite gritty.

The sample tested (Lab. No. 1862) worked up with 22 per cent of water to a mass that could be easily moulded. Its average air shrinkage is 5·1 per cent and average tensile strength 126 pounds per square inch.

The firing tests yielded the following results:—

Cone.	Fire shrinkage.	Absorption.
010	0	14·30
05	1·2	9·60
1	2·7	8·60
6	Fused	....

The clay burns to a deep but not bright red body. It will make a good serviceable brick, provided the stones are removed from the material before moulding. It is steel hard even at cone 05.

It is not unlikely that this clay could also be utilized for drain tile and pressed brick.

THE CLAY WORKING INDUSTRY.

In last year's report reference was made to the progress that was taking place in the clay working industry, and the prediction was offered that the coming year would see still further developments. It is gratifying to be able this year to state that these predictions have come true.

Not a few common brick plants have sprung into operation at different points, and others have enlarged their output.

Aside from this there have been several developments that are worth mentioning more specifically.

In the Dirt hills south of Moosejaw, a plant was under construction for using the Laramie clays for pressed brick and firebrick.

At Medicine Hat, which was already an important clay working centre of the Great Plains area, the most important event was the establishment of a pottery known as the Medicine Hat Potteries Company, for making earthenware and stoneware. At this same locality the Alberta Clay Products Company has enlarged its plant for making dry-pressed brick, fireproofing, and sewerpipe. The Purmal Brick Company, destroyed by fire, has been rebuilt and a new plant known as the Red Cliff Clay Products Company has started at Redcliff.

Calgary, a second clay working centre of the west, has likewise shown expansion of its clay working industry. The shale plants which were in operation at the time of our preceding visit are still in operation, and in addition to these two others have begun operations.

One of these is the Sandstone Brick and Sewer Pipe Company, which began operations in September, 1911. The plant is located a short distance north of Sandstone station. It has been equipped with a dry-press and temporary kilns, but the Company contemplates erecting a continuous one. They also propose to make sewerpipe, as they claim the shale is suitable for that purpose.

A second plant, under way, was that of the Tregillus Clay Co., located about 2 miles west of Calgary on the line of the Canadian Pacific railway. At the time of my visit only the grading for the plant had been done. I was informed that they proposed to manufacture brick, roofing tile, and fireproofing.

At Edmonton, the clay working industry has continued active in response to a naturally growing local demand.

In last year's report reference was made to a newly established shale brick plant, located near Edmonton South (then Strathcona). In the year some changes have taken place in the plant. During 1912 they were making dry-pressed brick, but stated it was also their intention to manufacture terra-cotta, drain tile, and sewerpipe. The plant consisted of a rotary dryer to dry the clay as it came from the bank, two Whittaker dry pans, piano wire screen, and four two mould dry presses. Burning was done in scove kilns. The clay shows a tendency to check.

The other plants at Edmonton are essentially as they were the year before.

In the Fraser valley west of Silverdale, a new brick plant has been started at Ruskin and one at Gilchrest.

A second plant known as the Kilgard Fire Clay Company, Limited, has been begun at Kilgard on the south side of Sumas mountain. The shales which will be utilized were described in an earlier report[1]. At the time it was visited in 1912, the plant had been equipped with a dry-press machine and dry pan. They had constructed two down draft kilns and expected to put up 6 or 8 more. The Company also intends to manufacture terra-cotta and firebrick.

Three companies have begun operations either on Vancouver island, or on the small islands adjoining its west coast. All of these aim to use the Northumberland shales. The plants started are those of the Mountain Brick and Tile Company, at East Wellington, near Nanaimo; the Dominion Brick and Tile Company on Gabriola island; and the Coast Shale Brick Company on Pender island.

In conclusion the writer wishes to comment on the possibilities which exist for the clay worker in the western provinces.

The results of the last three seasons work have, I believe, demonstrated the existence of a variety of clays in the western provinces of the Dominion. Some of these are already being

[1]Can. Geol. Surv., Mem. 24, p. 131, 1912.

worked with success at different localities, others are being worked either with indifferent results, or with none.

That there is a growing demand for different kinds of burned clay wares, will be admitted by all who are familiar with the situation in the region under discussion. Brick, both common and pressed, fireproofing, and sewerpipe are among the products most desired, but the larger cities like Winnipeg and Vancouver, are also calling for not a little terra-cotta.

The work carried on by the Geological Survey has demonstrated that the clays and shales found in the western provinces can be used for a variety of purposes, but it will be noticed that in no case has it been claimed that the clay or shale can be used for all sorts of purposes.

That a lucrative field is open to the conservative investor and competent manufacturer, goes without saying, but here as in any other country, failure often awaits the individual or company that goes ahead blindly, without first studying the situation. There is no doubt that in several cases plants have been started apparently for the purpose of selling stock, and claims are made that the material is good for making this, that, and the other kind of product, although there appears to be no evidence to back the statement.

Two facts are true, viz.: (1) that owing to the scarcity of local clay products, some inferior material is sometimes accepted in the market; and, (2) that on account of local conditions, such as high price obtainable for product, it is often possible to operate deposits which it would not pay to work in other regions which are more thickly settled and easier of access, by competing concerns.

Before a new plant is started, the ground should be carefully tested to make sure that a sufficient quantity of clay exists. This should be followed by a thorough and proper test of the material, made on samples that were properly taken.

Last and not least, comes the selection of the necessary machinery for preparing, moulding, and drying the clay.

If all these steps are carried out carefully, thoroughly, and competently, there should be no excuse for failure.

SUMMARY TABLE OF PHYSICAL TESTS.

LOCALITY	Laboratory number	Per cent water.	Air shrinkage.	Tens. strength Lbs. per sq. in.	Cone 010 Fire shrinkage.	Cone 010 Absorption.	Cone 05 Fire shrinkage.	Cone 05 Absorption.	Cone 03 Fire shrinkage.	Cone 03 Absorption.	Cone 1 Fire shrinkage.	Cone 1 Absorption.	Cone 3 Fire shrinkage.	Cone 3 Absorption.	Cone 5 Fire shrinkage.	Cone 5 Absorption.	Fusing Point. Cone.	Colour.	REMARKS.
Surface clay, Halbrite, Sask	1850	42	11·6		1·3	11	1·0	7·5			3	4·10					3		
Belly river shale, Bow Island, Alta.	1851	30	11·3		1·6	13·7	5·7	3·9			6	0·6						Cherry red	Can be moulded dry press.
" " " "	1852	25	10·6		1	12	4	3·7			7·7	0·3					4	Red	
" " " "	1853	25	9·6		0	11·6	0	8·6			1·4	8·8						Red brown	
" " " "	1854	22	9·6		0·3	17·9	1	15·2			3	12·2						Red	Would probably work dry press.
Big Coulee, 3 miles west of Medicine Hat	1857	26	6·6	281	0	21	0	17·5			5·4	14·0					6	Red	Flowed smoothly through die.
Glacial lake clay, Pocahontas, Alta.	1858	26	7	105	1	25·10	1·1	24·8	1	24·8	1·9	25·0					4	Cream	Dry press: cone 05, absorption 28·40%; cone 1, fire shr. 1·3%, abs. 23%
Cretaceous shale, Pocahontas, Alta.	1859	24	4	66	0	21·70	0·6	20·5			1·7	15·10					4	Buff	
Edmonton shale, Wolf creek, Alta.	1860	33	8·5	138	1·5	15·5	8·7	0	8·6	0	9·3	0					3–4	Red	Could probably be dry pressed. Flows through die.
Boulder clay, Prince Rupert, B.C.	1862	22	5·1	126	0	14·3	1·2	9·6			2·7	8·6					6		
Shale, junction Belly and St. Mary rivers, Alta.	1863	29	8·7	172	1·3	17·2	5	6·7			7·7	6·6					6	Red	Dry press: cone 1, 7·3% fire shrinkage, 8·40 absorption.
" " " " "	1864	28	7·7	55	1·2	14·1	8·3	1·9			8·8	1·8	4·8	0			4	Red	Dry press: cone 05, 3·3% fire shrinkage, 10·20 absorption.
Shale, Gleichen, Alta.	1865	34	12·3	50	1·2	11·9	6·3	1·3			6·3	1·0					4	Reddish	Dry press: cone 05, 6% fire shrinkage, 9% absorption.
Shale, Newcastle district, Vancouver island	1866	21	4·3	65	0·3	15·9	4·4	10	4·6	4·7	6·3	2·9					6	Red	
Belly river, 7 miles northeast of Lethbridge, Alta.	1868	25	8·0	60	0·3	12·7	0.3	9·6			1·0	8·1						Red	Good for common brick, not pressed brick.
" " " " "	1869																		Too sandy to mould.
" " " " "	1870	24	7	65	0	19·4	0	18·5										Reddish	
Shale, junction Belly and St. Mary rivers, Alta	1871		5		3·6	27·1			11	11·1	11·6	11·7						Brown	
Surface clay, Sixmile creek, near Ft. Steele, B.C.	1872	30	4·6	154	1·6	14·6	8	5·6	8	1·3	7·3	0					4	Reddish	Very sticky, but flowed through a die. Can be dry pressed.
Shale, junction Belly and St. Mary rivers, Alta.	1874	25	7·5		0·5	20·7	2	16·2									6	Red brown	Common brick clay.
Shale, Gleichen, Alta.	1875	26	7		1·6	14·7			4	11·7							7	Red brown	
Silty clay, Lake Windermere, B.C.	1876	Moulded only, dry press.															7	Cream	Dry press: fire shrinkage 0 and absorption 42% at cones 010–1.
Surface clay, Ford river, north of Revelstoke, B.C.	1877	35	6	110	0	19·2	2·3	13·2	5	9·3	7·7	4·7					5	Red	Dry press: cone 1, fire shr. 5%, abs. 10·80%; cone 05, fire shr. 8% abs. 18·5 %.
Shale, E. Wellington, Vancouver island, B.C	1878	19	4·6	70	0·4	12	1·4	8·75	3	5·5	3·4	4					5	Red	Dry press: abs. 12·5 at cone 05, 15·2 at cone 010.
Shale, Pender island, B.C	1879	19	3·8	90	0·8	14·7	1·7	11·5	2	8·7	5	4·4					5	Red	
Shale	1880	19	4	45	1	10	1·3	6·7	2	5·4	1·3	2·0					6	Red	
Shale, Sentinel, Alta.	1881	18	5·5		−1·1	10·4	8·1	5·6	3·3	4·1	5	3·6					5	Red	
" "	1882	19	5	70	0·7	12	3·5	8·2	4·5	4·8	4·7	4						Red	Dry press: cone 05, 1% fire shrinkage, 7% absorption.
Surface clay, Unity, Alta.	1884	20	7		0	20·6	0	19·5	0	19·5	0	20							
Benton shale, 1 mile west of Coleman, Alta.	1885	14	3	31	0	12·4	0	12·4	0	12·4	0	1					7	Grey brown	
Benton shale, 2 miles west of Blairmore, Alta.	1886	21	2·7	32	1	25·3	1	25	1	24	1	25					7	Grey buff	
Surface clay, Elko, B.C.	1887	30	8	200	0·4	20	0·6	18·4			0·6	18·8					5	Red	
Silty clay, Ft. Steele, B.C.	1889	24	1·6	40	s.s.	31			s.s.	30·9	0	32					8	Buff	
Soft shale, Coalmont, B.C.	1890	29	8·3	150	1·4	19·8	Cracked in burning and slaked in air.											Reddish	
Surface clay, Ruskin, B.C.	1891	31	6·6	138	1·7	21·7	3	15·2	6	12·5	9·6	4·90					4	Red	Dry press: cone 010, fire shr. 2%, abs. 18·3; cone 1, fire shr. 9, abs. 6·70 % Can be dry pressed. Flows smoothly through die.
Shale?, Princeton, B.C.	1895	12	.6		2·4	32·5			13·6	5·1	15·7	0·70						Buff	
Clay, coal mine, Coalmont, B.C.	1897	11·8	.7		2·5	1·0	0	0		0		0					22	Cream	Cracked and warped so in burning, could not measure shrinkage.
Shale, Gabriola island, B.C.	1898	19	5	50	2·8	14·4	6	3·89			8·7	1·0	9	0			5	Red	The weathered shale at least will dry press.
Surface clay, Silverdale, B.C.	1901	30	7	183	0	16·2	0·3	15·5			1·6	12·4					3	Red	Will dry press. Flows through die.
Shale, Roche Percee, Sask.	1903	36	Bricklets cracked in air drying.																
" " "	1905	37	Wet-moulded bricklets cracked.				Tests made in dry press ones.												
Shale, Graham island, B.C.	1906	18	4	50	0	14	0	13·1			1·6	11·3			3	9·0	20	Buff	
" " "	1907	19	5·6	60			0	11·2			1·3	10·6							Cone 9, fire shrinkage 3%, absorption 7·8%.
Cretaceous clay, South Fork, Alta.	1908	31	8	55	0	15·6	0·3	15·8	1	13·2	1	14					8	Buff, then grey	Air slakes if burned only to cone 010.
" " " "	1909	32	7·6	55	1	16·5	2	12·7			3	11·3					7	Buff, then grey	
Mixture of 1908 and 1909	1910	29	7	65	0·6	17·0													
Mixture, 50% 1886, 25% 1908, 25% 1909	1911	30	5	50	0	20·9	0	21·4			0	20·8					7		
Mixture, 50% 1885, 50% 1908	1912	30	6	65	1	20	1·3	13·5									7		
Shale, Milk creek, southeast of Blairmore	1913	22	5·6	55	1	17	2	14·3			2·7	5·5					4	Red brown	Will flow through die.
Shale, Edmonton, B.C.	1914	22	6		0	18					3·6	15·7					5	Red	
" "	1915	22	6		1	15					11	5						Red	
Surface clay, Monte creek, B.C.	1916		0		1	29												Red brown	Too sandy, but could be used if absolutely necessary to do so.
" " "	1917		0		2	32												Red brown	
Shale, Merritt, B.C.	1918	23	6															Red brown	

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CLASSIFIED LIST OF RECENT REPORTS OF GEOLOGICAL SURVEY.

Since 1910, reports issued by the Geological Survey have been called memoirs and have been numbered Memoir 1, Memoir 2, etc. Owing to delays incidental to the publishing of reports and their accompanying maps, not all of the reports have been called memoirs, and the memoirs have not been issued in the order of their assigned numbers, and, therefore, the following list has been prepared to prevent any misconceptions arising on this account.

Memoirs and Reports Published During 1910

REPORTS

Report on a geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont.—by W. H. Collins. No. 1059.

Report on the geological position and characteristics of the oil-shale deposits of Canada—by R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories— by Joseph Keele. No. 1097.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 1. *No. 1, Geological Series.* Geology of the Nipigon basin, Ontario—by Alfred W. G. Wilson.

MEMOIR 2. *No. 2, Geological Series.* Geology and ore deposits of Hedley Mining district, British Columbia—by Charles Camsell.

MEMOIR 3. *No. 3, Geological Series.* Palæoniscid fishes from the Albert shales of New Brunswick—by Lawrence M. Lambe.

MEMOIR 5. *No. 4, Geological Series.* Preliminary memoir on the Lewes and Nordenskiold Rivers coal district, Yukon Territory—by D. D. Cairnes.

MEMOIR 6. *No. 5, Geological Series.* Geology of the Haliburton and Bancroft areas, Province of Ontario—by Frank D. Adams and Alfred E. Barlow.

MEMOIR 7. *No. 6, Geological Series.* Geology of St. Bruno mountain, Province of Quebec—by John A. Dresser.

MEMOIRS—TOPOGRAPHICAL SERIES

MEMOIR 11. *No. 1, Topographical Series.* Triangulation and spirit levelling of Vancouver island, B.C., 1909—by R. H. Chapman.

Memoirs and Reports Published During 1911

REPORTS

Report on a traverse through the southern part of the North West Territories, from Lac Seul to Cat lake, in 1902—by Alfred W. G. Wilson. No. 1006.

Report on a part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers—by W. McInnes. No. 1080.

Report on the geology of an area adjoining the east side of Lake Timiskaming —by Morley E. Wilson. No. 1064.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 4. *No. 7, Geological Series.* Geological reconnaissance along the line of the National Transcontinental railway in western Quebec—by W. J. Wilson.

MEMOIR 8. *No. 8, Geological Series.* The Edmonton coal field, Alberta—by D. B. Dowling.

MEMOIR 9. *No. 9, Geological Series.* Bighorn coal basin, Alberta—by G. S. Malloch.

MEMOIR 10. *No. 10, Geological Series.* An instrumental survey of the shore-lines of the extinct lakes Algonquin and Nipissing in southwestern Ontario—by J. W. Goldthwait.

MEMOIR 12. *No. 11, Geological Series.* Insects from the Tertiary lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906—by Anton Handlirsch.

MEMOIR 15. *No. 12, Geological Series.* On a Trenton Echinoderm fauna at Kirkfield, Ontario—by Frank Springer.

MEMOIR 16. *No. 13, Geological Series.* The clay and shale deposits of Nova Scotia and portions of New Brunswick—by Heinrich Ries, assisted by Joseph Keele.

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MEMOIR 21. *No. 15, Geological Series.* The geology and ore deposits of Phoenix, Boundary district, British Columbia—by O. E. Le Roy.
MEMOIR 24. *No. 16, Geological Series.* Preliminary report on the clay and shale deposits of the western provinces—by Heinrich Ries and Joseph Keele.
MEMOIR 27. *No. 17, Geological Series.* Report of the Commission appointed to investigate Turtle mountain, Frank, Alberta, 1911.
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MEMOIR 25. *No. 21, Geological Series.* Report on the clay and shale deposits of the western provinces (Part II)—by Heinrich Ries and Joseph Keele.
MEMOIR 30. *No. 40, Geological Series.* The basins of Nelson and Churchill rivers—by William McInnes.
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MEMOIR 32. *No. 25, Geological Series.* Portions of Portland Canal and Skeena Mining divisions, Skeena district, B.C.—by R. G. McConnell.
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