MEMOIRS 65 AND 66

CLAY AND SHALE DEPOSITS OF THE WESTERN PROVINCES

(PARTS IV AND V)

BY

H. RIES AND J. KEELE.

GEOLOGICAL SURVEY
DEPARTMENT OF MINES
OTTAWA
1915

CANADA
DEPARTMENT OF MINES
HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.

GEOLOGICAL SURVEY

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No. 53, GEOLOGICAL SERIES

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No. 1453

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PART IV.

INTRODUCTORY.

In the three reports already published on the clay and shale resources of the western provinces, the plastic materials occurring in the different geologic formations have been discussed in some detail, and many tests given. It cannot be assumed that with these four reports the last work on western clays will have been printed, for in no case during the work has it been deemed practicable to go many miles from the railway, as clay will not stand long hauls. There are in the west many hundreds of square miles of territory, which have not yet been made accessible by the railways, but in which there are no doubt important clay deposits still to be found. This is perhaps more true of the mountainous region lying between the Great Plains and the Pacific coast. The great forested area of central and northern Vancouver island is also likely to yield some plastic materials of commercial importance.

The present report does not aim to cover a large number of localities, but refers to some of those which it was not possible to visit in other seasons. In addition a very few were revisited for the purpose of obtaining some additional information. The important localities, included in the field season of 1913, were: Blue mountain near Whonnock, B.C.; the Nanaimo district, B.C.; Princeton, B.C.; Wyckliffe, B.C.; Cranbrook, B.C.; Creston, B.C.; Kilgard, B.C.; Blairmore and Coleman, Alberta; Passburg, Alberta; South Fork, Alberta.

BLUE MOUNTAIN, B.C.

This mountain contains one of the strongest shale deposits thus far discovered in the province of British Columbia, and ranks next to Sumas mountain.

Blue mountain is situated about 4 miles north of Whonnock on the Canadian Pacific railway. The gentle slopes of the mountain are heavily wooded, and show practically no outcrops, until an elevation, said to be 2,500 feet, is reached. Above this in several steep ravines there are a number of exposures of shale on the property of the Blue Mountain Refractories Company, Ltd., of Vancouver. The claims are in sec. 2, in both the NE. and NW. $\frac{1}{4}$ sec. in tp. 4, range 4, W. 7th mer., in the New Westminster district.

The general section of sedimentary beds consists of sandstones, sandy shales, and fine-grained conglomerate, which rest in turn on granitic rocks of the Coast Range batholith. No opinion is ventured here regarding the age of these stratified rocks, except to state that they are probably not a portion of the Eocene delta deposits of the Fraser river as these do not reach the elevation.[1]

The best section seen was exposed in a ravine which is tributary to that of Gold stream, and must be at least 250 feet thick, the lower 150 feet being largely red shale, with a conchoidal fracture. The underlying rock, the granite, appears to be rather uneven, for while the shales extend down the tributary to its junction with Gold stream, on the latter they are first found at least 100 feet higher.

At the juncture of the main stream and its tributary there is a heavy bed of red shale, with an exposed face at least 25 feet high. It is indistinctly stratified, and breaks into irregular pieces. This red shale is also found outcropping up the ravine of Gold stream, but here it is underlain by a coarse conglomerate consisting of boulders of igneous rock from 1 to 2 feet in diameter, and which in turn overlie the granitic rock.

Above the red shale there is a blue shale, and similar material is found outcropping up the tributary ravine near an old tunnel.

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[1] Inter. Geol. Congress, Guide Book No. 8, Part III, p. 271, 1913.

Before referring to the properties of the shale a further statement should be made regarding its location. The material outcrops on the south side of Blue mountain at an altitude of about 2,500 feet, and about 7 miles from the Fraser river at Whonnock. It is out of the question to locate the plant at the deposit, and, therefore, the shale would have to be brought down to the plant which could be placed near the river and railway. For transporting the raw material, an aërial tram would probably serve best and there seem no obstacles to the installation of such a method of transportation.

The method of working the deposit should also be carefully considered. Where the best exposures occur the mountain slope is steep, and the shale would have to be worked by underground methods, but if the deposit is of any great extent, the possibility exists that it could be found at other points on the mountain side, where the slope was less steep, and hence a certain amount of open-cut mining could be carried on.

The samples tested were five in number, and their properties are given below.

Red Shale (*Lab. No. 1942*).

This represents the bright red shale found at the junction of the two creeks. It is smooth and dense, but when ground dry and then mixed with water has fair working qualities, although its plasticity is not very high, and it did not flow well through an annular die. I believe that tempering in a wet pan would greatly improve its plasticity.

It took 18 per cent of water to work it up to a plastic mass, whose air shrinkage was 5 per cent, and average tensile strength when air dried, 25 pounds per square inch.

This plastic mixture was formed into test bricklets which were fired at seven different cones, with the results tabulated following:

Laboratory Sample No. 1942.

Cone	Fire shrinkage %	Absorption %
010	1	17·20
05	2	16·07
1	3	13·63
3	4	6·90
5	5	1·28
7	Past vitrification	
9	Viscous	

Reference to these figures and their graphic representation in Figure 1, shows that the shale has a low fire shrinkage, but that the absorption while moderate up to cone 1, drops rapidly after that.

The shale burns to a good red brick which becomes steel hard at cone 05.

The material when worked up in a plastic condition could be employed for common or face brick, especially if the latter were re-pressed. It might also serve for making the rough-surface face brick so much used at the present time. While I would hesitate to recommend this shale for sewer-pipe or paving brick, I believe that it could be mixed with a more plastic and more easily vitrifying clay for making these two kinds of ware. Another use which suggests itself is the employment of this shale for the making of red quarry tile. These form a very desirable product for paving courts and porches. They are about 8 inches by 8 inches by $\frac{3}{4}$ inch.

Samples of the red shale were also tested in the dry press form after grinding and passing through a 20-mesh sieve. No trouble was experienced in moulding the shale, but unless it is finely ground the brick have a granular appearance. The colour of the dry-pressed bricklets was a bright red, but it was necessary to burn them to cone 1 to obtain a hard product. At cone 010 the material had no ring; at cone 05 it was still too soft. At cone 1 the fire shrinkage was 2·5 per cent and the absorption 12·70 per cent. Both these figures are perfectly allowable.

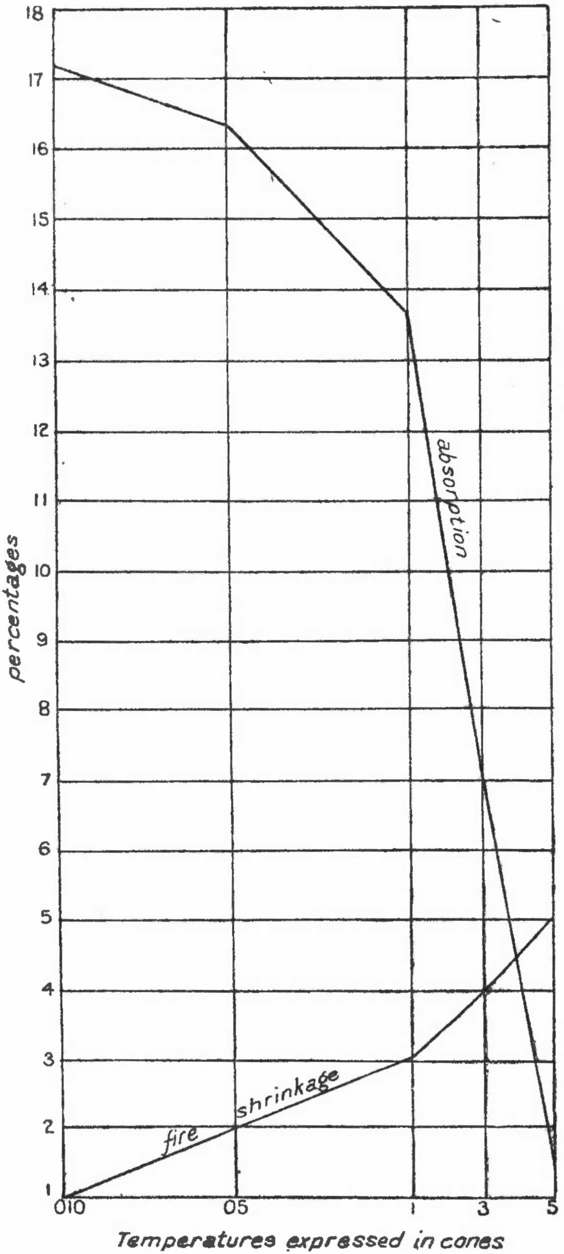

Figure 1. Fire shrinkage and absorption curves of shale, Laboratory Sample No. 1942, from Blue mountain.

The tests on a mixture of the red shale and the blue shale are described after discussion of the latter.

Blue Shale (Lab. No. 1943).

This is Turner's blue shale, and represents the best of the series tested, for it can be classed as a fireclay.

Like the other shales from this locality it is fine grained and dense, but when ground dry through a crusher set to one-sixteenth inch, it did not develop a very plastic mass, in fact the plasticity was not sufficient for satisfactory moulding.

A second lot of the material was, therefore, ground up wet, as would be done if a wet pan were used, and this resulted in considerable improvement, for the clay so ground developed excellent plasticity. Its air shrinkage of 8 per cent was a little high, but in practice it would probably be lower.

These wet-moulded bricklets were then burned from cone 010 to cone 15 with the following results:

Laboratory Sample No. 1943.

Cone	Fire shrinkage %	Absorption %
010	2·8	17·60
05	4·4	15·55
1	5·6	10·35
7	7·0	7·00
9	7·4	5·1
15	11·5	2·6
30	Fused	

These tests are also represented graphically in Figure 2. The bricklets burned to a buff coloured body which was steel hard at cone 05, but at cone 010 the body was too soft although not excessively porous. As the tests will show the shale burned to a fairly dense body even at cone 1, without excessive fire shrinkage. The fact that it fused at cone 30 shows that the material represents a fair grade of fireclay.

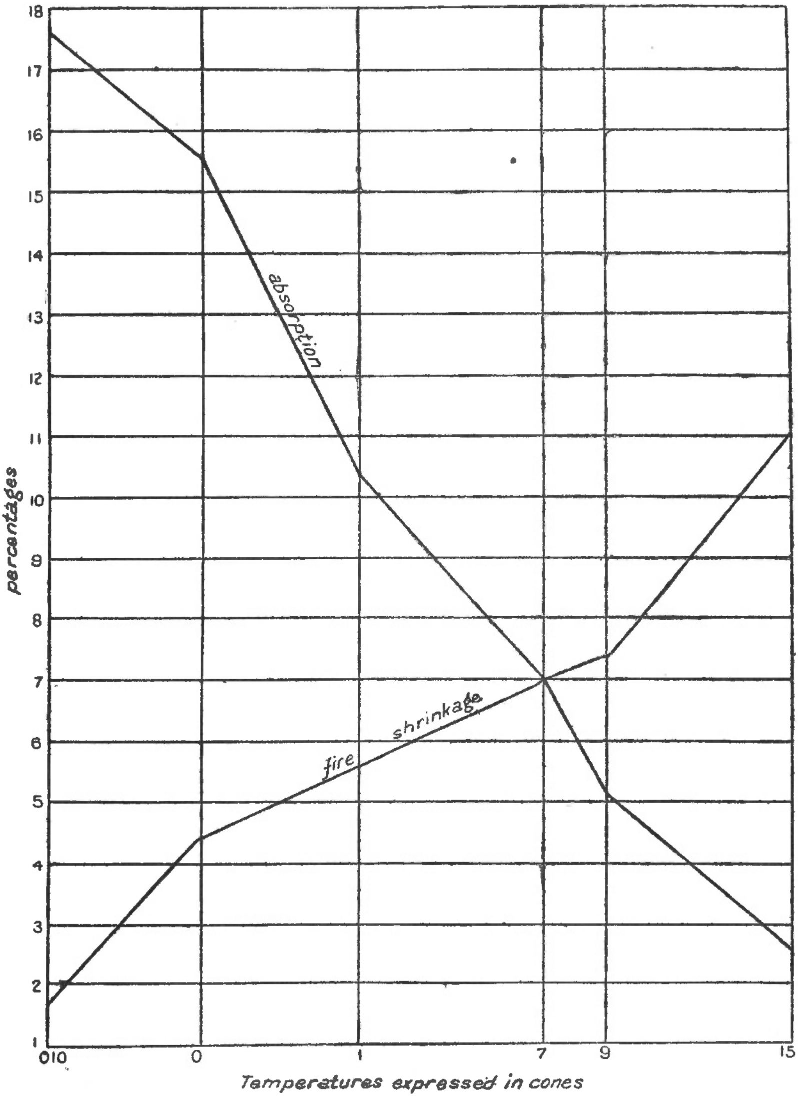

Figure 2. Shrinkage and absorption curves, shale, Laboratory Sample No. 1943, Blue mountain.

In its plastic condition it could be utilized for making pressed brick, and also firebrick, but if used for the latter purpose some grog would have to be added to the mixture. It is also nearly as refractory as the fireclays found in Sumas mountain. I think this shale could be employed as an ingredient of terra-cotta. Some of the dry-ground shale was moulded dry-press, and gave a very attractive, smooth, mottled buff brick, which in my opinion is as handsome and pleasing as any that I have made from Canadian clays. To give a hard dry-pressed product it requires burning to cone 1. At cone 1 the fire shrinkage was 6·4 per cent and the absorption 9·10 per cent. At cone 5 the fire shrinkage was 6·4 per cent and the absorption 6·4 per cent.

Grey Shale (Lab. No. 1944).

This is from the tunnel up the tributary stream, already mentioned, and while grey when fresh, turns reddish on exposure to the weather.

It is less dense and less coherent than the two already described, for after dry grinding in the crusher, it gives a mass of good plasticity when mixed with 29 per cent of water. The average air shrinkage was 8·5 per cent, and the tensile strength was about 25 pounds per square inch. The shale did not flow very well through an annular die, although I believe it would behave much better if ground wet, as in a wet pan.

The wet-moulded bricklets made from the clay were nearly steel hard at cone 010, and completely so at cone 05. They burned to a reddish buff colour. The fire shrinkage was not excessive at the lower cones, and the absorption was moderate.

The burning tests on the bricklets are as given below:

Laboratory Sample No. 1944.

Cone	Fire shrinkage %	Absorption %
010	3	13·72
05	3·3	11·25
1	5·4	9·28
3	6·5	6·63
5	7	5·5
9	8	3·8
15	8·6	1·2

This clay is not a fireclay, as it fuses below cone 27.

We have here a shale that would when wet-moulded burn to a dense brick. There is also a possibility that it might work for sewer-pipe, although the colour of the body might not be altogether satisfactory, as engineers prefer a red body. If no trouble is experienced in forcing it through a die, I believe the material could also be employed for fireproofing.

Some bars 12 feet by 1 foot by $\frac{3}{8}$ inch were made up, in order to see how ribbons of it would behave, with reference to its use for roofing tile. These were supported on knife edge supports placed 10 inches apart, and fired slowly up to cone 1. The strips held their shape and showed no signs of sagging.[1]

The burning tests of the wet-moulded bricklets are graphically represented in Figure 3.

No difficulty was experienced in making dry-press bricklets of the shale. These showed an absorption of 17·21 per cent at cone 010; 12·50 per cent at cone 05, and 6·12 per cent at cone 1. The bricklets were steel hard at cone 05.

Mixture of Blue and Grey Shales (Lab. Nos. 1943 and 1944).

As dry grinding did not give a mass of sufficient plasticity when the blue shale (Lab. No. 1943) alone was used, and as the grey shale (Lab. No. 1944) was of good plasticity, it was deemed desirable to try a mixture consisting of 50 per cent of each. This gave a mass that could be moulded without any difficulty, and burned to a buff colour. The air shrinkage was 6·6 per cent which is lower than that of 1944 or 1943 (after wet grinding). The bricklets were steel hard at cone 05.

The burning tests on these wet-moulded bricklets, which are also expressed graphically in Figure 4, follow:

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[1]For earlier tests of this nature see Can. Geol. Surv., Memoir 25, p. 94, 1913.

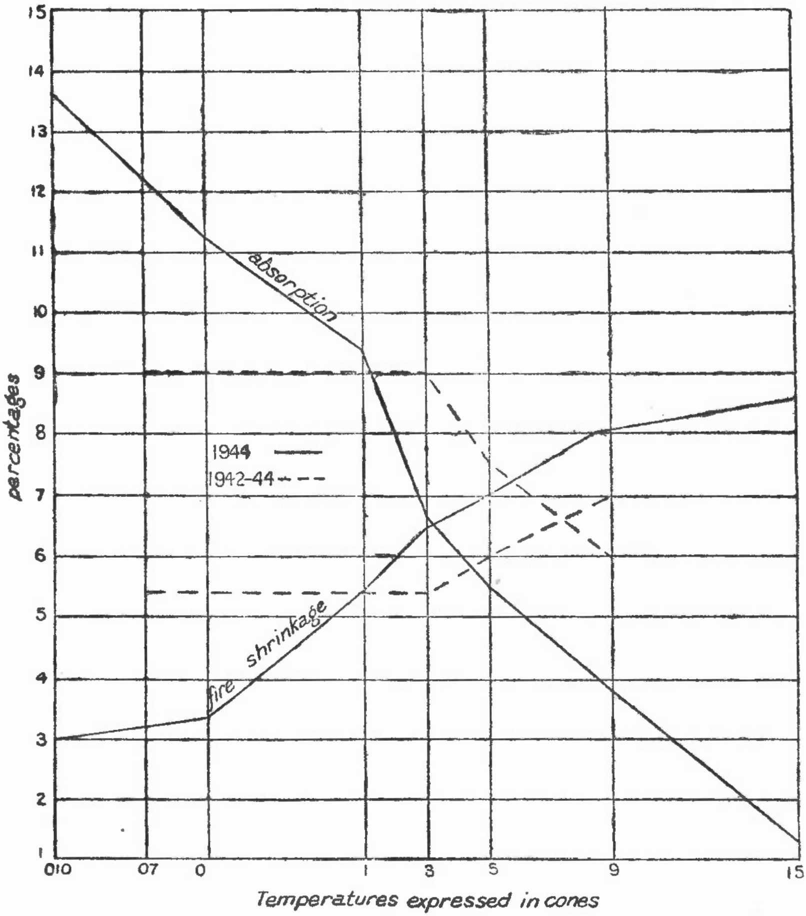

Figure 3. Shrinkage and absorption curves of Laboratory Sample No. 1944, and mixture of Laboratory Samples Nos. 1942 and 1944, Blue mountain.

Combined Laboratory Samples Nos. 1943 and 1944.

Cone	Fire shrinkage %	Absorption %
010	3·0	12·50
05	4·4	11·25
1	5·0	11·43
3	6·0	10·50
7	6·0	9·25
9	6·4	9·00
15	7·3	4·00

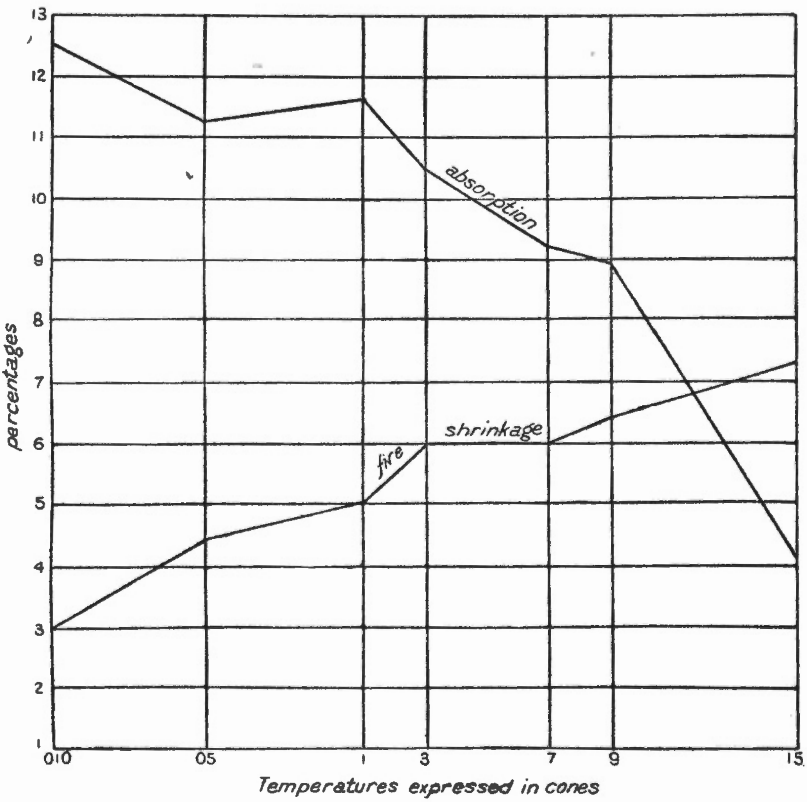

Figure 4. Shrinkage and absorption curves, mixture of Laboratory Samples Nos. 1943 and 1944, Blue mountain.

If we compare the shrinkage and absorption curves in Figures 2 and 3, with those in Figure 4, it brings out some interesting features, for we see that the fire shrinkage and absorption instead of being a mean of those expressed by the other two clays, average higher in the case of the absorption and lower in the case of the shrinkage.

Mixture of Red and Grey Shale (Lab. Nos. 1942 and 1944).

As the red shale (Lab. No. 1942) when dry ground was not highly plastic, and the grey shale (Lab. No. 1944) was strongly so, a mixture of equal parts of the two was made up. This gave a nice, smooth, plastic body which moulded easily and had an average air shrinkage of 5·6 per cent. The bricklets burned steel hard at cone 07, and were reddish in colour, but not the bright red of 1942 above. The burning tests yielded the following figures:

Combined Laboratory Samples Nos. 1942 and 1944.

Cone	Fire shrinkage %	Absorption %
07	5·4	9·0
1	5·4	9·0
3	5·4	9·0
5	6·0	7·6
9	7·0	6·0

In Figure 3 the tests on 1944 and the mixture of 1942 and 1944 are shown graphically. Figure 1 gives the tests on 1942. Comparison of these three sets of shrinkage and absorption curves, brings out the fact that up to cone 1, the fire shrinkage is higher and the absorption lower than in either of the shales alone, but that above cone 1, the curves of the mixture lie between the curves of the single shales, but approach more closely to those of 1944.

I think this mixture could be used for face brick or fireproofing, but it hardly burns dense enough for sewer-pipe, and is not vitrified even at cone 9.

White Clay (Lab. No. 1945).

There is some doubt regarding the exact amount of this clay present in the deposit, for its occurrence seems to be rather irregular. It is to be hoped, however, that a quantity of it may be found, for it is a material of excellent plasticity, which worked up with only 18 per cent of water. The air shrinkage was 5 per cent, being the lowest of any clays tested from this mountain.

The shale burns to a cream or bright buff colour and is nearly steel hard at cone 010. The fire shrinkage is not high at the lower cones. It will also be seen from the tests that the shrinkage increases between cones 1 and 5, and that the shale is practically vitrified at cone 15 (see Figure 5). It does not appear to be as refractory as the blue shale (Lab. No. 1943). The burning tests were as follows:

Laboratory Sample No. 1945.

Cone	Fire shrinkage %	Absorption %
010	3·3	14·25
05	4·0	14·18
1	6	10·40
5	9·4	4·65
7	9·0	4·6
15	9·6	2·2

If enough of this clay is found, I believe it could be used for making face brick, or in a mixture for architectural terra-cotta. The material also lends itself to dry-pressing.

Summary.

We have in this series of materials from Blue mountain an interesting set of shales. In thickness of deposit they remind one of the shales found in Sumas mountain, south of Mission Junction, but present certain marked differences. They are softer than the shales worked at Kilgard and Abbotsford, and

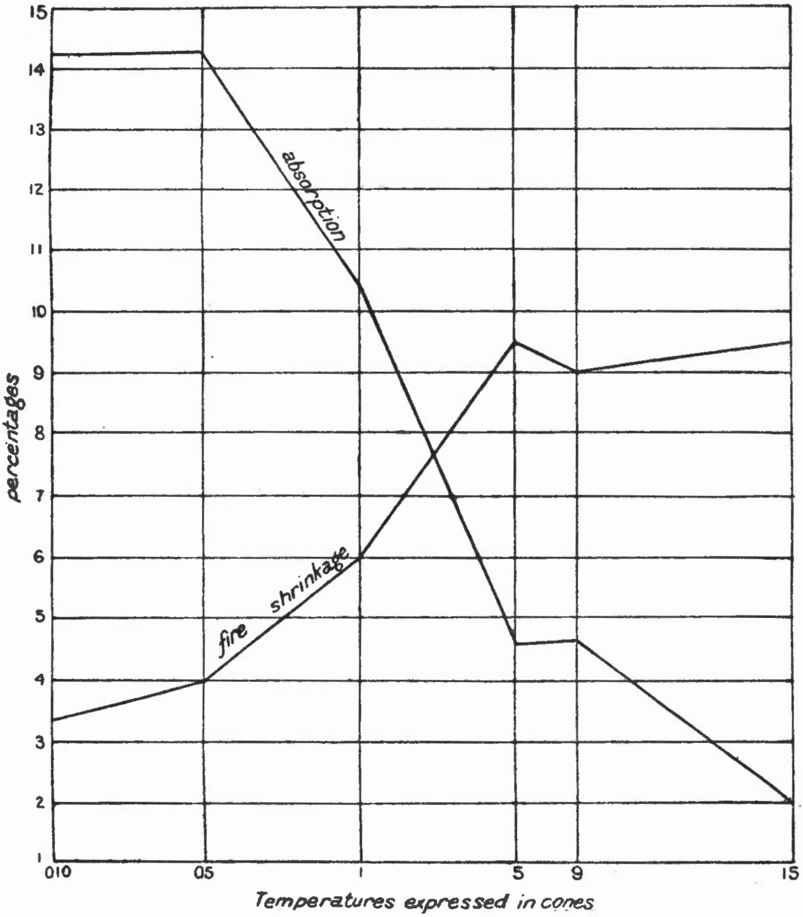

Figure 5. Shrinkage and absorption curves, shale, Laboratory Sample No. 1945, Blue mountain.

hence grind up easier, but differ from many of these in showing a slightly higher shrinkage, at the lower cones especially. What their extent is, cannot be definitely told until borings have been made and trenches dug.

We can say that these clays if properly handled should make the basis of a face-brick industry; that one at least, the blue shale (Lab. No. 1943), is a fireclay; and that there seem possibilities for using these materials in terra-cotta, fireproofing, and sewer-pipe manufacture.

KILGARD, B.C.

In the report covering the field season of 1910,[1] some attention was paid to the shale deposits of Sumas mountain. The deposits, as previously mentioned, are a portion of the Fraser delta constructed in Eocene time. Since they represent delta formations, it is not unnatural to expect them to show some variation, and as a result we find beds of sandy and clayey material alternating, all of them now more or less consolidated; and yet, the variations are not rapid, so that each kind of material may form a bed or lens of considerable size.

When Sumas mountain was visited in 1910, one plant was in operation at Clayburn, viz., that of the Clayburn Fire Clay Co. Ltd., while a second one was in contemplation, at Kilgard on the south side of the mountain. The first of these plants has been in active operation since, and additions have been made to it, including a unit for manufacturing fireproofing. The plant at Kilgard has been completed, but at the time of my visit was idle. It was most completely equipped for manufacturing dry-pressed brick, sewer-pipe, and firebrick (Plate I).

In the two years separating my visits to this locality, considerable clearing had been done on the southern exposure of the mountain, above the works, so that a much better chance was afforded for viewing the section. For this reason we give below a more complete statement than could be supplied in our earlier report.

At the bottom of the slope, an opening had been made in slightly kaolinized volcanic rock. Most of it is fine grained, rather free from iron, and occasionally shows scattered grains of pyrite. The purer parts of this have been called china-clay, although it is not really such. It is, however, of refractory nature. This rock is called No. 1.

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[1]Ries and Keele, Can. Geol. Surv., Memoir 24-E, p. 125, 1912.

Above this rock No. 1 is a bed of fireclay known as No. 2, which lies beneath a thin bed of coal, while the latter is covered by shale. Between the No. 2 bed of fireclay and the wagon road are several beds of shale. Just below the level of the wagon road, there are two beds of fireclay known as No. 3 and No. 4, which are separated by a parting of coal 6 inches thick. The No. 3 clay is 5 to 6 feet thick, and the No. 4 consists of a lower portion 14 to 18 inches thick, and an upper portion about 6 feet thick. A tunnel about 175 feet long had been run in, taking out both 3 and 4.

About 50 feet higher up is No. 5 which averages 6 to 8 feet in thickness. This has been penetrated by a 275-foot tunnel with about 400 feet of side entries. Some 20 feet above No. 5 is No. 6 with a thickness of 7 to 9 feet and a good sandstone roof. This shale had been penetrated by a tunnel 85 feet long.

No. 7, coming next above, is 6 feet thick.

No. 8, still higher up, is 6 to 8 feet.

No. 9 is about 7 feet thick.

No. 10 averages 13 to 14 feet in thickness.

No. 11 is a smooth shale 8 to 10 feet in thickness.

No. 12, which is the highest of the shale beds, is probably not less than 40 or 50 feet in thickness. It is reddish brown in colour and somewhat sandy. The several beds from 3 up are separated by beds of sandstone and sandy shale.

Character of the Shales.

This may be briefly summarized as follows:

No. 2. This makes an excellent No. 1 firebrick whose analysis was:—

Silica	62·80 per cent.
Alumina	35·00 " "
Ferric oxide	1·80 " "
Lime	0·20 " "
Magnesia	trace
	99·80

No. 3. This burns to a somewhat dense body, and brownish colour at cone 4. It is semi-plastic, and can be mixed with No. 5 to make a face brick. If used alone it may work for sewer-pipe.

No. 4. The lower bench burns to a pleasing brown colour, and gives a slightly denser brick than the upper bench. The upper bench makes a firebrick. No. 4 alone is used for the best grade of firebrick although it is said to be not quite as good as No. 2. The upper No. 4 is thought to be suitable also for making coke oven brick.

No. 5. This is used for dry-pressed face brick which burns to a buff colour at cone 10. These also take a good flash.

No. 6. The shale from this bed has been employed for dry-press brick. It has also given favourable results when used for sewer-pipe.

No. 7. This shale is buff burning, but had not been used.

No. 8. The bed is divisible into three benches which beginning at the top, burn respectively to a buff, grey buff, and grey colour.

No. 9. This is a plastic, buff-burning material.

No. 10. This is a sandy, red-burning shale, which vitrified about cone 2. It is claimed to be suitable for drain tile and paving brick.

No. 11. A red-burning shale, regarding which little else was definitely known.

No. 12. This is known to be red-burning, but has not been used.

NANAIMO AND VICINITY.

The east coast of Vancouver island, especially south of Nanaimo, continues to be a scene of somewhat unwarranted activity in the clayworking industry. I feel justified in saying activity, for this does not necessarily imply the accomplishment of positive results. The basis of this activity is the shale of the Nanaimo series. The somewhat unsatisfactory character of this material has been commented on in two previous reports,[1]

[1]Memoir No. 25, p. 78, et. seq., and Memoir 47, p. 64.

but development still goes on. The chief objection to this shale is its hardness and grittiness, so that even when finely ground it does not develop much plasticity. Occasionally when well weathered the material for the first few feet below the surface is a little more tractable, but most of the outcrops seem to have been very little altered by the weathering agents.

In order to bring out this point let us refer to the shale being worked by the Dominion Brick and Tile company on the west side of Gabriola island, opposite Mudge island. The beds exposed here (Plate II A and B) are a little less gritty than many of the others of this series, although they contain scattered sandstone layers. When this plant was visited in the summer of 1912, only a small opening had been made and this was in the buff-coloured somewhat weathered material. By the summer of 1913, however, the excavation had penetrated the blue shale which was harder, less plastic, showed lower fire shrinkage and higher absorption.

To bring out the comparison more clearly, the tests of the two are placed in parallel columns, while the absorption and fire shrinkage are shown graphically in Figure 6.

Laboratory Samples Nos. 1928 and 1927.

	Buff or weathered shale (Lab. No. 1928)	Blue or unweathered shale (Lab. No. 1927)
Water required	2·2%	18%
Air shrinkage	7·6%	5%
Plasticity	Good	Only fair
Colour burned	Red	Red
Cone 010		
Fire shrinkage	1·4	0·6
Absorption	13·43	12·54
Cone 05		
Fire shrinkage	4·4	4·0
Absorption	9·18	12·07
Cone 1		
Fire shrinkage	7·4	6·00
Absorption	0·78	2·49

	Buff or weathered shale (Lab. No. 1928)	Blue or unweathered shale (Lab. No. 1927)
Cone 3		
Fire shrinkage	Nearly fused	5·00
Absorption		3·00
Cone 010		
Fire shrinkage	0	
Absorption	14·33	11·88
Cone 05		
Fire shrinkage	5·00	4·7
Absorption	11·07	10·63
Cone 1		
Fire shrinkage	7·5	
Absorption	1·0	

In the dry-press the unweathered seemed to burn denser than the weathered shale. The buff shale burns to a deeper red. While this particular shale burns to a good red product, still there is not a little loss from cracking. There is a possibility that this shale could be put through a stiff-mud die, but it is not suggested.

Not far from here, in 1913, two properties were being developed. One of these was on the shore of Vancouver island just west of Mudge island. The shale here (Lab. No. 1933) was very gritty, and even when finely ground had very little plasticity; in fact some would call it non-plastic. Indeed it was impossible to mould it in the wet condition. We did succeed in making some dry-press bricklets and these burned to a red colour. Their absorption was 24·90 per cent at cone 010; 11·11 per cent at cone 05; and 2·24 per cent at cone 1. I cannot regard this as an attractive proposition.

Only a few hundred yards away on the south shore of Mudge island (Plate IIIA), another shale deposit was to be developed, and preparations were under way to establish a brick-yard. The shale here was as gritty and untractable as that just described, and the geologic conditions were much worse. The shale forms a steep bank along the water's edge, and is overlain by massively

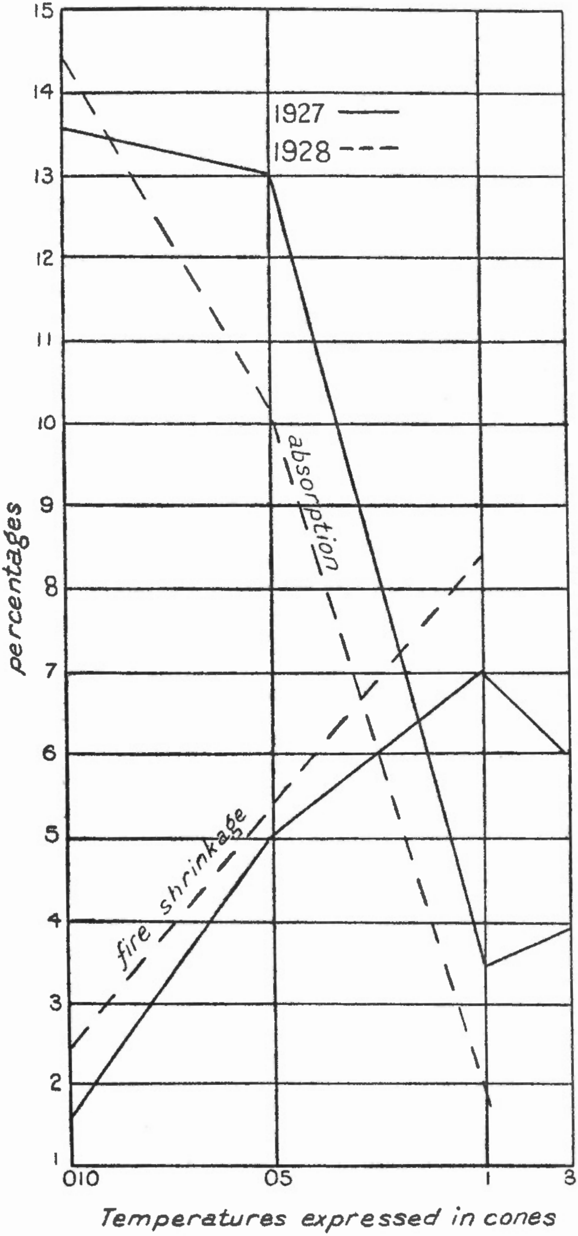

Figure 6. Shrinkage and absorption curves of unweathered (1927) and weathered (1928) shale, Gabriola island, near Nanaimo, B.C.

bedded sandstone. The bank cannot be quarried in very far from the face without undermining the sandstone. Moreover the sandstone extends down to the water's edge a short distance to both the east and west (Plate IIIB) of the shale bank. The successful development of this deposit both on account of its location and character seems very doubtful.

PRINCETON, B.C.

The rocks around Princeton consist chiefly of sediments of Oligocene age: sandstones, shales, and conglomerate with coal seams. These shales are of variable character, ranging from sandy to fine-grained ones, and from those which are very carbonaceous to others which seem to carry little carbon. These different types may alternate with each other and with coal seams. There are no extensive outcrops of shales at Princeton, the best observed being in the cut near the cement works 2 miles east of Princeton, and on the east side of the Similkameen river, at the end of the wagon bridge.

In last year's report on the western clays and shales[1] reference was made to a very plastic clay from the coal mines at Coalmont, which proved to be of refractory character. As only a small sample of it was obtainable, another visit was paid to the locality this year in order to study it further, but the mine had been closed down.

An effort was then made to obtain samples of any available clay or shale beds around Princeton, other than those already examined. The first of these was found in the Empire mine, 2 miles east of the town. Here, the coal which dips about 45 degrees south, is overlain by a coarse arkose, but between the latter and the coal is a very persistent but not always sharply defined, bed of clay which varies in thickness from 6 inches to 2 feet, but is usually nearer the latter figure. It is of dark brownish grey colour and contains scattered particles of carbonaceous matter. There would be no profit in working the clay alone, but it could be mined in connexion with the coal.

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[1]Memoir 47, Part III.

A sample of the material (Lab. No. 1931) was tested in some detail. It was so smooth and plastic that no trouble was experienced in running it through an annular die, but the tiles cracked on air drying. A mass of the clay was then mixed with water for other tests. This took 29 per cent of water, and its air shrinkage of 9·3 per cent was somewhat high. The average tensile strength when air-dried was 96 pounds per square inch. The clay burns buff at the lower cones, but changes to brown at the higher ones. It is steel hard at about cone 05.

The other tests were as below:

Laboratory Sample No. 1931.

Cone	Fire shrinkage %	Absorption %
010	1·7	16·76
05	4·1	13·25
1	6·3	9·04
3	7·4	7·85
5	7·4	3·2
9	—	0·9
15	Nearly fused	

Even at cone 9, the clay showed fused spots. The material is not a fireclay, but it burns to a good colour for pressed brick, and could be dry pressed.

There is not enough clay in sight to warrant the establishment of a brick plant, but if one were started for common brick manufacture in the vicinity, and there was an occasional call for dry-press brick, this material could be drawn upon to feed a small press.

A sample (Lab. No. 1919) represents a shale outcropping in the railway cut between the Empire mine and the Cement mill. The shale appears to be moderately soft and the beds dip to the southward. The upper part of this shale mixed with the surface soil is said to have been utilized for making common brick, but they were rather porous. Many highly plastic clays containing large quantities of colloidal matter have a greasy

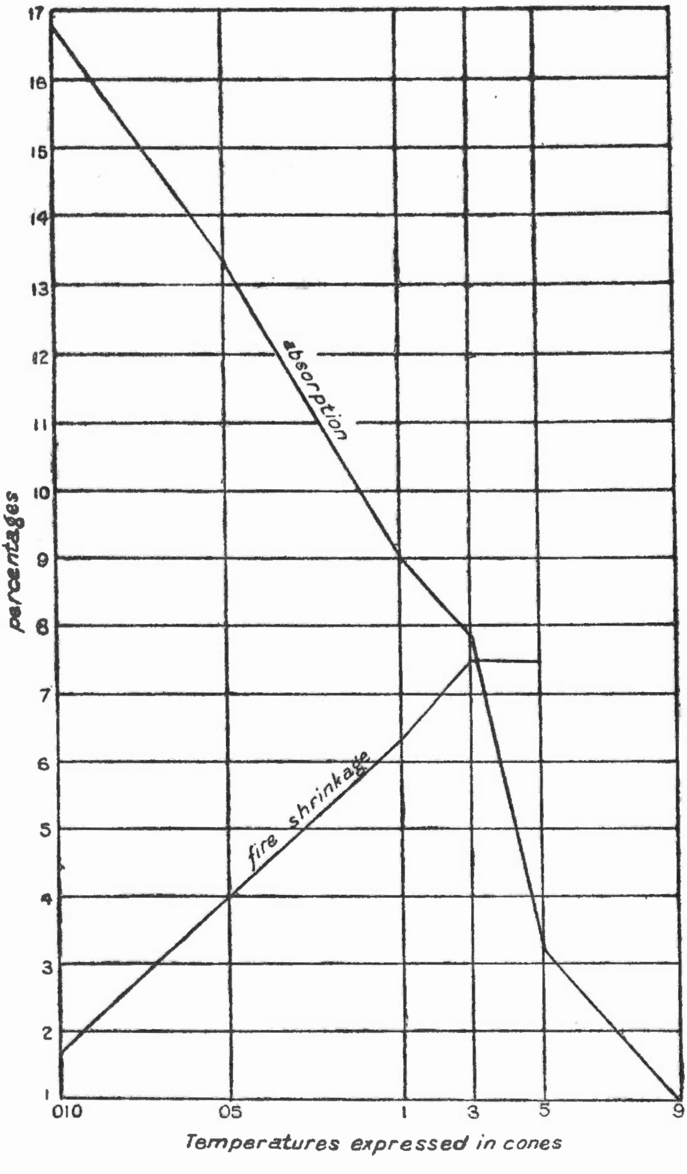

Figure 7. Shrinkage and absorption curves of preheated shale from Empire mine, Princeton, B.C.

look, but this shale shows none. However, when ground and mixed with water to a plastic mass, it cracked badly in drying, showing the high air shrinkage of 13·6 per cent. The latter alone would make the clay unfit for use by any plastic method, unless some material of low plasticity could be added to it. It is possible that it could be mixed with some of the hard gritty shale that outcrops farther down the track below the cement works.

The shale alone can, however, be moulded dry press, according to our experiments, but the bricklets did not yield a good ringing product much below cone 1. Their colour after burning was red, and the body was somewhat granular, but not sufficiently so to be objectionable. At cone 010, the dry-press bricklets were not steel hard, or even hard enough for use.

At cone 05, the bricklets had an absorption of 22·25 per cent, and at cone 1 of 6·60 per cent.

Tests on Preheated Clay (Lab. No. 1919).

A sample of the clay was preheated to 300 degrees C., which reduced its stickiness when wet as well as its excessive air shrinkage, so that it could be moulded without much difficulty. The air shrinkage of the preheated clay was 7 per cent, which as can be seen, was considerably less than that of the untreated material.

These bricklets were burned at 3 cones as follows:

Laboratory Sample No. 1919.

Cone	Fire shrinkage %	Absorption %	Colour
010	1	17·10	Dark pink
05	3·3	10·20	" "
1	7	6·10	" brown

The clay was steel hard at cone 1, and nearly so at cone 010. It showed some scum due to the presence of soluble salts in the clay. For graphic representation of the tests see Figure 8.

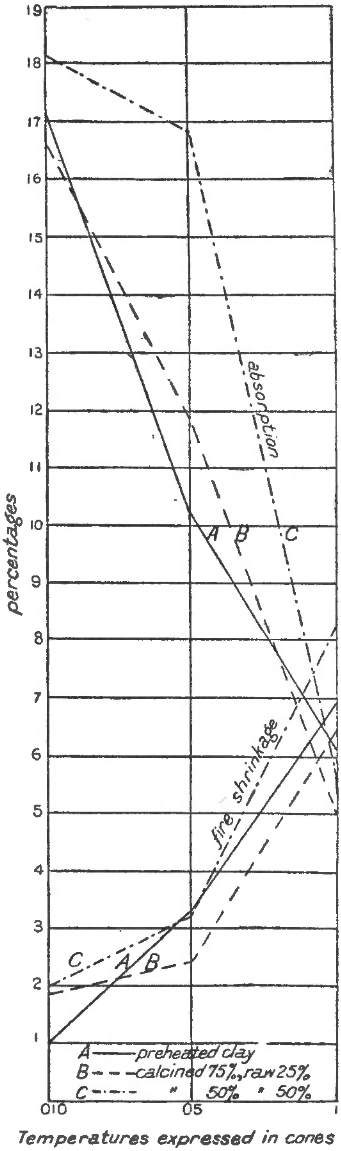

Figure 8. Shrinkage and absorption curves of raw and calcined clay mixtures, Princeton, B.C.

Tests on Mixtures of Calcined and Raw Clay.

In a second series of tests sample No. 1919 was heated to dull redness, which had the effect of destroying the plasticity. A mixture (Lab. No. 1950) was then made up consisting of 75 per cent of the calcined clay, and 25 per cent of the raw material. This mixture when worked up with water gave a mass that could be moulded without any trouble. Its average air shrinkage of 8 per cent was a little high. The clay burned to a salmon colour up to cone 010, and a dark red from cone 05 to cone 1. It was nearly steel hard at cone 010 and completely so at cone 05. The other figures of the burning tests were as follows:

Laboratory Sample No. 1950.

Cone	Fire shrinkage %	Absorption %
010	1·85	16·58
05	2·4	11·76
1	6·6	4·92

The next mixture (Lab. No. 1951) consisted of 50 per cent of the calcined clay and 50 per cent of the raw material. This when worked up with water was fairly sticky and very plastic, but no trouble was experienced in moulding it. The average air shrinkage was 6·5 per cent and the average tensile strength 81 pounds per square inch. The clay burns red and is nearly steel hard at cone 010.

Laboratory Sample No. 1951.

Cone	Fire shrinkage %	Absorption %
010	2	18·16
05	3·3	16·80
1	8·3	5·52

Comparison of 1950 and 1951 shows the latter to have a higher fire shrinkage and higher absorption, which is not what we might expect.

The shrinkage and absorption curves of the three clays are shown in Figure 8.

The material is not a fireclay. It could be made into red brick, but if used alone would have to be preheated before it could be moulded by any plastic process.

PRINCETON COAL AND COKE COMPANY.

The mine of this company is located on the east side of the Similkameen river, east of Princeton. The coal and associated shales dip southwest, and an exposure of coal and shales is seen along the river bank to the northwest. The coal company is working a bed of coal that is from 20 to 24 feet thick. There is a roof of black shale over the coal which is of no value.

About 14 feet above the coal and underlying an upper coal bed, is a greyish, greasy-looking clay (Lab. No. 1934) that weathers to a white colour. The bed of it runs about 2 feet in thickness. The very light colour of the dried material suggested that it might be rather free from iron, and hence it was desirable to determine whether it was a fireclay. While it turned out to be non-refractory, it was nevertheless extremely interesting. The material is exceedingly sticky and plastic, as well as being remarkably fine grained, and it is quite evident that its high plasticity is due to its content of colloidal matter.

The following partial chemical analysis was made:

Total silica	75·20 per cent
Hydrous silica	3·66 " "
Alumina	11·39 " "
Ferric oxide	1·83 " "
Carbonaceous matter	0·21 " "

The shrinkage and absorption curves are given in Figure 9.

In order to determine whether the hydrous silica and the carbonaceous matter were evenly distributed, or confined to the finer particles of the clay, a sample of it was stirred up in

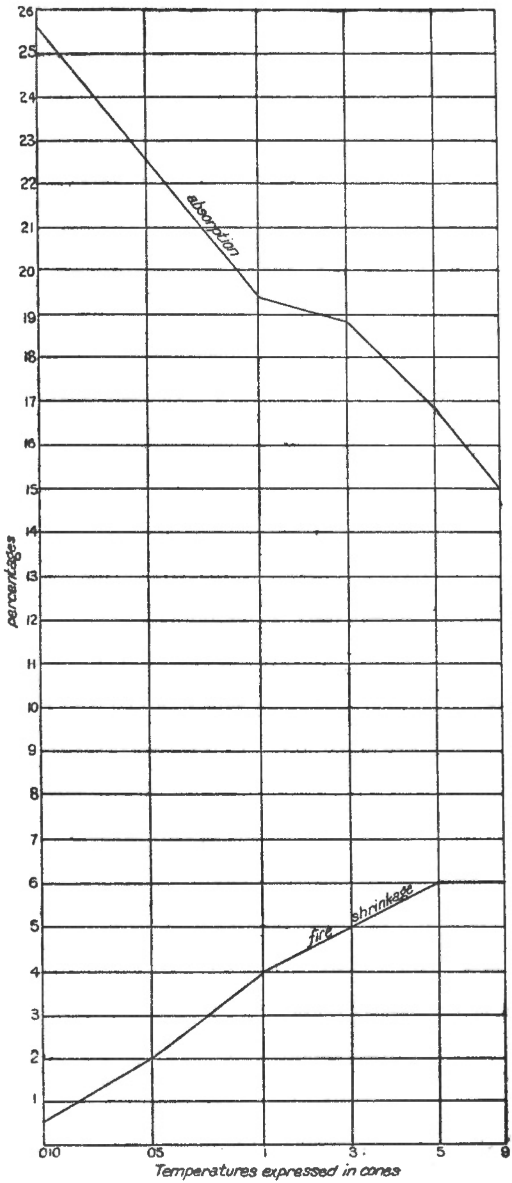

Figure 9. Shrinkage and absorption curves of preheated clay, Laboratory Sample No. 1934, Princeton Coal and Coke company.

water, and that portion which remained suspended was examined with the result that it showed:—

Hydrous silica.....................	9·25 per cent
Carbonaceous matter...............	0·20 " "

One might expect from the comparatively low iron content that the material was a refractory clay, but it is not, for it fuses at cone 15. The fusion may no doubt be helped by the hydrous silica which appears to exert a strong fluxing action.

Further comments on the plasticity of this clay will be left until the other Princeton materials have been discussed.

Turning now to the physical tests of this clay, it was found that the raw material required 49 per cent of water to work it up to a pasty mass. This was an excessive amount and the bricklets cracked and shrunk to such a degree in the air drying that nothing could be done with them. A sample of the clay was, therefore, heated to 300 degrees C. This had the effect of almost completely eliminating the air-cracking and reduced the air shrinkage to 5 per cent.

The bricklets moulded from this preheated clay were then burned at different heats up to cone 15 at which it fused, the surface of the test piece becoming glassy. The clay burns to a porous, buff-coloured body, and is rather light in weight. The surface shows a network of small cracks which developed in the burning and not in the drying.

The burning tests were as follows:

Laboratory Sample No. 1934.

Cone	Fire shrinkage %	Absorption %
010	0·6	25·15
05	2·0	25·50
1	4·0	19·36
5	5·0	18·80
9	6·0	16·80
12	6·0	15·00
15	Fused	

The under clay (Lab. No. 1932) forms a bed about 2 feet thick below the main coal bed. The material is very sticky, highly plastic, and apparently carbonaceous in its character. On account of its excessive plasticity the clay cracked badly even when dried slowly at room temperature, and had an air shrinkage of 11 per cent. A sample of the clay was then preheated to 300 degrees C., ground and moulded. It was less plastic after preheating, and the air shrinkage was reduced to about 8·5 per cent, but the clay still cracked badly. As it was not considered practicable to heat it above 300 degrees C., no further tests were carried out on the material.

NORTH OF PRINCETON.

The Tertiary shales and sandstones outcrop along the Great Northern railway at the southwest end of the tunnel, but the beds are usually sandy, and the shale in small lenses.

The Plasticity of the Princeton Clays.

All of the clays described from the Princeton district are excessively plastic and sticky, and it may not be out of place to say a few words regarding their plastic qualities. A theory quite widely accepted now, but not fully proven, is that the plasticity of clay is due to colloidal material of either organic or inorganic nature. The reason for saying that the theory is not fully proven is because there is strong reason to believe that other factors besides colloids, may, sometimes, at least, be operative.

In order to get some further light on this subject, three very plastic clays were selected from the Princeton district,[1] including samples 1919, 1934, and 1932, and a fourth sample, (Lab. No. 1765) from Tofield, Alberta. Fifty-gram samples of each of these were weighed out, and shaken up in 1000 cc of distilled water. The jars containing these were allowed to stand 24 hours.

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[1]The laboratory tests on these were carried on by N. B. Davis.

Samples were then taken by means of a pipette from different depths, and the size of the larger particles measured in each case. One clay (sample 1919, see Plate IV A) which appeared to have considerable absorbed salts, settled in a few hours. The others showed considerable material remaining in suspension even at the end of 20 days. At the end of this period, pipette samples were again taken from different depths, and another set of measurements made. This time the particles in suspension in 1934 and 1932 were so small that they could not be seen with a magnification of 600 diameters. The particles in 1765 on the other hand were visible, and measured 0·002 millimetres in diameter.

The sizes of the particles remaining in suspension in clays 1934, 1932, and 1765 at the end of 24 hours are shown by the curves in Figure 10.

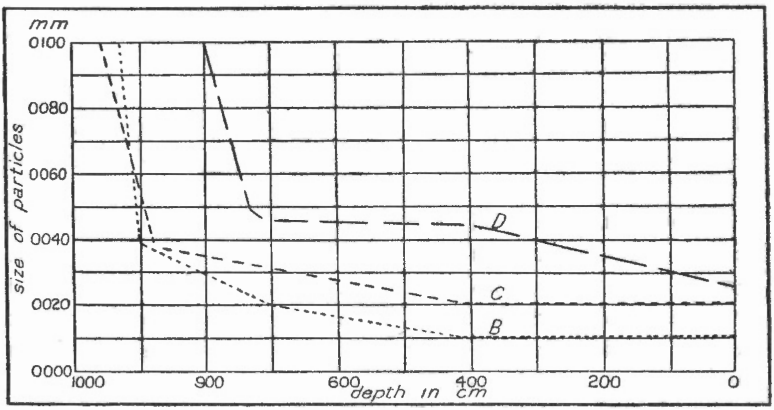

Figure 10. Curves showing size of particles in suspension at end of 24 hours in clays of high colloid content.

A study of the curves indicates that something is probably present in the case of 1765, which causes larger particles to remain in suspension than in the case of clays 1934 and 1932. This difference in the suspended material suggested a possible difference in the nature of the colloidal material present, so determinations of colloidal matter were made in samples 1934, 1932, and 1765.

In extracting the hydrous silica, the relative depth of colour of the solution in 1934, 1932, and 1765 suggested that the per cent of colloidal organic matter increased towards 1765. These determinations are given below:

	1934	1932	1765
Hydrous silica......................	3·66	0·76	0·12
Carbonaceous matter................	0·21	0·65[1]	1·10

Comparing these three sets of determinations we see that the hydrous or colloidal silica decreases from 1934 to 1765, but that the carbonaceous matter of colloidal nature increases in the same direction. Now it is known that organic colloids are supposed to have a greater effect on plasticity than inorganic colloids, and both 1932 and 1765 are more plastic than 1934. The action of the organic colloid is probably two-fold. In the first place it may increase the viscosity of a mixture of water and suspended clay particles, and in the second place it may act as a protective colloid, and hold the clay particles in suspension. It is significant then, that in 1765 which contained more organic colloids, that after 20 days the clay particles remaining in suspension in 1765 were not only larger but more numerous than in the case of 1934 and 1932.

Now as to the conditions of formation of the clays in the Princeton basin, the fact that coal beds were laid down in the Tertiary formation carrying the clays, shows that there must have been considerable organic matter in the water in which the clay was laid down. No doubt much of this organic matter was in colloidal form, and was mixed with the clayey sediment. It may be asked why the organic matter in the clay is in a colloidal condition, while that of the coal is not. The latter became inspissated, while that in the clay may never have dried out to this condition; or if it did, prolonged exposure to moisture filtering along the clay beds may have changed it back to the colloidal form.

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[1]The total quantity of carbonaceous matter (2·67%) was determined, but some of this was coaly material. It was estimated colourimetrically that 0·65 per cent was colloidal.

CRANBROOK, B.C., AND VICINITY.

The calcareous silts in the valley of St. Mary river at Cranbrook, have been referred to in last year's report, and their similarity to the silts of the Columbia valley commented on. These materials were very calcareous, cream burning, and yielded a highly porous brick.

In the year 1913 another yard was established about 2 miles west of Cranbrook by Mr. Hanson (Plate V A). The deposit worked here, lies not in the main valley but behind a ridge, and slightly above the terrace level in the valley proper. It seems to be a separate basin or small lake deposit, of very different character from the valley silts, as it is much more plastic and of better working quality. The clay is stratified, in layers one-half to 1 inch thick, separated by thin laminæ of sand, and there are only a few inches of soil overlying it. A thickness of 5 feet had been exposed (Plate V B). Like the valley silts it is calcareous, but not enough so to make a cream-coloured product.

It is sufficiently plastic to flow through a tile die. The clay (Lab. No. 1935) worked up with 20 per cent of water, and had an average air shrinkage of 5·4 per cent, and an average tensile strength of 87 pounds per square inch. Both wet-moulded and dry-press bricklets were made with satisfactory results. The wet-moulded bricklets burned to a pink colour at low cones, and then red if well burned, but were not steel hard unless fired to cone 05, although thay had a good ring even at cone 010. The burning tests of the wet-moulded bricklets are as follows:

Laboratory Sample No. 1935.

Cone	Fire shrinkage %	Absorption %
010	0	26·43
05	1·0	20·80
1	10·7	0·10
3	Fused	

It will be seen from these tests that although the clay is not sufficiently calcareous to burn buff, it nevertheless shows some of the characteristics of a calcareous clay, in its rapid shrinkage and vitrification between cone 05 and cone 1. It should be burned at cone 05 if possible.

The burning tests of the dry-press bricklets were as follows:

Laboratory Sample No. 1935.

Cone	Fire shrinkage %	Absorption %
010	Too soft for use	
05	0·3	31·64
1	11·00	0·97

The dry-press bricklets at cone 05 were pink in colour, fine grained, and had a good ring, but the absorption was too high. At cone 1 the shrinkage was excessive and the colour dark brown. If dry-press brick were made of this clay they would probably have to be burned about cone 03 for the dual purpose of getting less absorption than at cone 05 and of avoiding the high shrinkage developed when burned at cone 1. The accompanying diagram Figure 11 shows in an interesting manner the relative sizes of the bricks at cone 05 and cone 1.

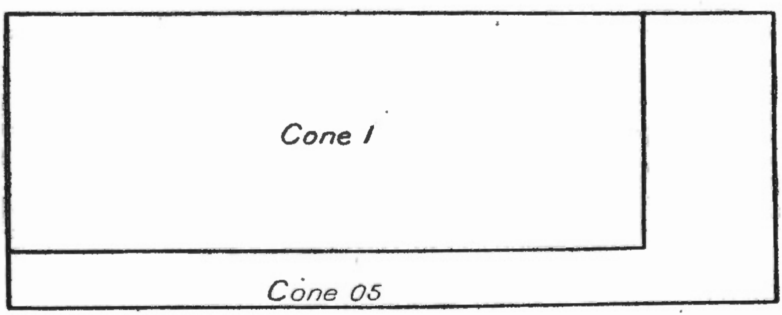


Figure 11. Sketch showing relative size of Hanson's clay bricklets moulded dry oven and burned at cone 05 and cone 1.

As to the uses of this clay, it could be and is manufactured into common brick. It would, I believe also, make drain tile. It lends itself to dry pressing. Lastly the smoother portions of the deposit could, I think, be moulded into earthenware such as flower pots. Mr. Hanson showed me some interesting and very creditable pieces of rustic pottery that had been modelled by hand from the material in his clay pit. At the time of my visit the product consisted wholly of common brick. The plant was equipped with pug mill, rolls, and side-cut stiff-mud machine. Drying was done on pallet racks, and burning in scove kilns.

Along the railway track at Wyckliffe station (Plate VI A) 6 miles northwest of Cranbrook, there is a strong outcrop of Pre-Cambrian metargillite. The material is a very hard schistose rock, which in some beds contains considerably more quartz than in others. A tunnel has been driven along one of the less quartzose beds, and at this point a sample for testing was taken. The material is not at all promising looking, and the only reason it was tested was because it was said to have been used for making brick, to line the smelter at Marysville, B.C. Even when finely ground, the material (Lab. No. 1941) had no plasticity so that it could not be wet-moulded. Some of it was then ground up very fine, moistened slightly with water and dry-pressed. These tests yielded the following results:

Cone 010. No ring to brick, body soft, colour red, absorption 12·58 per cent.

Cone 05. Little ring, absorption 12·28 per cent.

Cone 1. Fire shrinkage 1 per cent, bricklet barely steel hard, absorption 9 per cent.

The material is not recommended for brick manufacture, for it can barely be moulded even by the dry-press process, and even then has to be very finely ground.

In looking for good clays in this region, Mr. S. J. Schofield of the Geological Survey, pointed out to the writer a bed of dark grey clay located along the north bank of St. Mary river, about 4 miles above the St. Eugene mission. The bed outcrops at the base of a high bank, and has a thickness of about 5 feet. As the overburden is considerable it could not be worked as an open pit, and could only be extracted by means of drifts. Neither is there evidence of a large quantity of the material. There would, however, be enough to supply a small pottery, the idea being that the material might be used for earthenware.

The clay was plastic, although it contained much very fine grit, and took 29 per cent of water for mixing. It had an average tensile strength when air dried of 57 pounds per square inch, and an air shrinkage of 4·2 per cent. It burns to a pink colour and does not become steel hard until cone 1. The fire shrinkage is not high up to cone 05, and while the absorption appears to be, it is often so in common earthenware made from some clays. The clay could probably be improved by washing, so as to remove fine grit.

The following are the fire tests on the bricklets:

Laboratory Sample No. 1946—Wet-moulded bricklets.

Cone	Fire shrinkage %	Absorption %
010	2	27·60
05	5	25·00
1	11	8·80
3	13	0·00

Laboratory Sample No. 1946—Dry-press bricklets.

Cone	Fire shrinkage %	Absorption %	Colour.
010	Soft, no ring when struck		
05	Fairly hard	26·88	pink
1	Not steel hard	16·82	

It would hardly be worth while to attempt making any dry-press forms of the clay.

CRESTON, B.C.

Goat river, a tributary of Kootenay river, joins the latter near Creston, and the Canadian Pacific railway follows the narrow valley of this stream from Goatfell to Creston. Along the line of the railway there are in this distance a number of clay cuts, which have given considerable trouble by sliding. These cuts, which are mostly of silty, laminated clay, are especially numerous between Kitchener and Erickson. Some of the cuts show stony or boulder clay, and in these there may be lenses of the laminated clays. All of these laminated clays are very silty and somewhat calcareous.

The deposits are not in all cases large enough to be worked, nor where they outcrop along the railway track, it might not in all cases be practicable to work them. They represent, however, a common type of clay in this region, and since they are best exposed along the railway, our samples were taken from these points.

A sample (Lab. No. 1930) was taken from along the railway about one mile northeast of Canyon station. It is a fine-grained silty material of fair plasticity, but at the same time exhibits the resistance to pressure, so characteristic of silty clays. It worked up with 23·8 per cent of water, had an average air shrinkage of 3·1 per cent, and an average tensile strength of 25 pounds per square inch. On account of its silty character the clay did not give results when moulded dry-press, but it did lend itself to the plastic method of working, and the test bricklets were formed in this manner. They burned to a pink colour, but did not become steel hard until cone 1, and in fact did not give a brick with real good ring unless burned to cone 05.

The other details of the burning tests are as follows:

Laboratory Sample No. 1930.

Cone	Fire shrinkage %	Absorption %
010	0	18·60
05	1	16·20
1	9·4	4·76
3	9·5	4·7
7	nearly viscous	

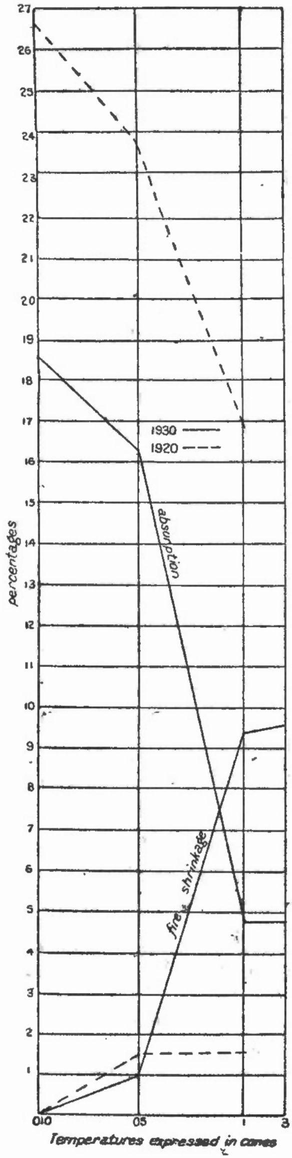


Figure 12. Shrinkage and absorption curves of clays from near Creston, B.C.

It will be seen from these tests that the clay does not become very dense until above cone 05, and that the great decrease in absorption at cone 1 is accompanied by a strong increase in shrinkage (Figure 12).

The clay is not plastic enough to flow through a die, and the only use suggested is for making common brick by the soft-mud process.

The best clay bank exposed along the railway track in the stretch mentioned is in the large cut at Goat canyon (Plate VI B). It is a typical silty clay, which bakes to a hard mass in dry weather, and runs easily in wet weather. The clay (Lab. No. 1924) is of greyish-yellow colour, somewhat calcareous, and of fair plasticity, but not enough to flow through a tile die. It required 30·8 per cent of water to work the clay up to a plastic mass, which had an average air shrinkage of 4·9 per cent. The average tensile strength when air dried was 45 pounds per square inch. The clay like many other silty ones swelled slightly at cone 010, and its fire shrinkage was practically zero up to cone 05. By cone 1 the shrinkage had increased to 10·3 per cent. The absorption was high in every case except cone 1, and ran as follows—cone 010, 25·80 per cent; cone 05, 24·00 per cent; cone 1, 0 per cent. This peculiar behaviour is due in part to its silty nature, and in part to its lime carbonate contents. The clay burns pink, but is not steel hard until fired above cone 05.

It is at best only a common brick clay.

Along the road fron Creston to Goat canyon, and opposite the site of Lisk and Slater's old saw mill, there is a long outcrop of reddish brown clay, with very little stony material. The deposit, as nearly as could be determined without boring, is probably 15 or 20 feet thick. There is room here for a brick plant, and the locality is about 1000 feet by an air line from the railway. Similar clay outcrops at other points near by.

This material (Lab. No. 1920) is quite different in its nature from that in the railway cuts mentioned above, being less sandy to the feel and denser, but like the others is somewhat calcareous. It took considerable water to work it up, viz., 35 per cent, but yielded a mass that was sufficiently plastic to flow through a tile die. The average air shrinkage was 7 per cent, and the average tensile strength when air-dried, 90 pounds per square inch. This was almost double that of the Goat Canyon clay. The clay burned to a red colour, and the bricklets had a good ring even at cone 010. The fire tests were as below:

Laboratory Sample No. 1920.

Cone	Fire shrinkage %	Absorption %	Colour
010	0	26·40	salmon
05	1·5	23·50	
1	1·7	16·87	red
3	Fused		

The curves are given in Figure 12.

The clay could be used for common brick as it is plastic enough to work. It burns hard at a low heat, and the only objection to it is the somewhat high absorption. However, the latter is not necessarily an indication of low durability. The clay could, moreover, be utilized in making drain tile, provided these did not have to be vitrified, but if they were burned to cone 1, the absorption would not be excessive. Even though the absorption of the brick made from this clay is somewhat high, the clay is better than several others which are used for brick in southern British Columbia. If the project of lowering the level of Kootenay lake is carried out, so as to unwater the delta lands south of Kootenay Landing, the drain tile which could be made from this clay should prove of value for draining these reclaimed lands.

Along the Erickson road, about 2½ miles from Creston, this same kind of clay again occurs, and here is not far from the railway track.

FORT GEORGE, B.C.

During the summer of 1913 the writer was shown two samples of greyish white clay which were said to have come from Giscome Portage, 30 miles above Fort George. One of the clays is quite sandy while the other is smoother and contains only fine sand. The smoother and more plastic of the two clays is said to form a lower bed, and the more sandy material an upper bed, the whole being described as overlain by river gravel containing pebbles of quartzite.

Only small samples of each were available, so but few tests could be made on them, and these are given below. No. 1953 is known as the plastic clay, and 1954 as the sandy clay. The latter is decidedly gritty to the feel and even in appearance (when dry), but nevertheless its plasticity is good.

The burning tests are given below. It is quite possible that the more plastic clay may be of fair refractoriness, but the other on account of its sandiness would not stand as much heat. Both are nearly steel hard at cone 07. The air shrinkage of sample No. 1953 was 6 per cent. The burning tests were as follows:

Laboratory Sample No. 1953.

Cone	Fire shrinkage %	Absorption %	Colour
07	2·3	17·10	cream
1	3	15·40	buff
3	3	15·5	buff
5	5	10·20	
9	6·0	8·0	buff

The air shrinkage of sample No. 1954 was 4 per cent. The burning tests were as follows:

Laboratory Sample No. 1954.

Cone	Fire shrinkage %	Absorption %	Colour
07	1	14·0	cream
1	1	14·00	buff
3	1·5	13·5	buff
5	2·5	11·0	
9	2·5	9·5	buff

Nothing can be said regarding the extent of this deposit; but it is worth looking into. In its present location, there seems no immediate local use for the product, but if made into fire-brick or face brick, these could be shipped into Prince Rupert or Vancouver.

COLEMAN, ALBERTA.

In last year's report reference was made to the black Benton shale occurring west of Coleman, in the SW. ¼, sec. 7, tp. 8, range 4, W. 5th mer. This is a black shale, which dips into the hill, and is exposed for about 30 feet up the face of it, above which there is gravelly overburden about 30 feet thick (Plate VII).

The shale tested last year represented fresh material taken from a tunnel on the quarter section mentioned, and while it was found to be possible to make dry-press brick from it, the use of this material was not encouraged. This year some further tests have been made in order to do these shales full justice, and because the request was made that we mix this material with some other clays found in the vicinity.

Since weathering often improves a shale, tests were made on a sample of the black shale, which had been lying at the mouth of the assessment tunnel for about a year. This material (Lab. No. 1940) was as black and carbonaceous as the fresh rock, and had very little plasticity even when ground fine. Indeed, it is practically no better than the fresh shale, and could not be worked up in the plastic form.

The wet moulding having failed, it was then tried dry-press. The clay can be so moulded if it contains enough moisture. It burns to a red brick. The test bricklets were fired at different cones as follows:

Cone 010, bricklet granular, no ring, but held together. Absorption 12·32 per cent, which is not high.

Cone 05, ring poor, absorption 12·23 per cent.

Cone 1, good ring, bricklets steel hard, absorption 10·72.

It is possible to make a red dry-press brick from this shale, if care is used, but I cannot regard the attempt as hopeful.

The material is of excessive leanness, low coherence, and must be fired slowly and carefully on account of the carbonaceous matter which it contains.

A second sample tested was a shale from near this same locality (Lab. No. 1922) (No. 2 of Bradley). This had practically no plasticity and dry-press bricklets could be made of it only with difficulty. I do not see much advantage in using this material.

A third sample, Lab. No. 1926 (No. 3 of Bradley), was obtained from near the water-fall, upstream from the assessment tunnel. This was a clay of very different character from the shale. It is a slightly calcareous material of low plasticity, which required 22 per cent of water to mix it. The average air shrinkage was 4·3 per cent, and the average tensile strength not over 20 pounds per square inch. For this reason the air-dried bricklets are not very strong.

The clay burns to a reddish body, which is nearly steel hard at cone 010, and completely so at cone 05. The bricklets showed small fused spots and a tendency to crack slightly.

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

Laboratory Sample No. 1926.

Cone	Fire shrinkage %	Absorption %	Colour
010	0·8	18·20	pink
05	1·0	15·12	dark pink
1	1·4	14·73	dark pink

The absorption at cone 05 is not excessive and the fire shrinkage is low; but I question whether the clay could be used for anything but common brick. Better results would be obtained if the clay were dry pressed.

Finally a mixture (Lab. No. 1949) was made up consisting of equal parts of 1926 and 1940. This gave better results than any of the three materials used alone. It worked up to a mass of fair plasticity with 14 per cent of water, which is not excessive. The average air shrinkage was low, being 4 per cent, and the average tensile strength when air dried was 25 pounds per square inch. This mixture could be either wet-moulded or dry-pressed, and each was tried.

The wet-moulded bricklets burned to a light red, but not as deep a colour as 1940 alone. The burning tests were as below:

Laboratory Sample No. 1949.

Cone	Fire shrinkage %	Absorption %
010	0·5	15·00
05	1·0	14·10
1	1·0	11·12

A dry-press bricklet burned at cone 1 showed 9 per cent absorption.

This mixture could be used for common or pressed brick, but probably nothing else.

Since the Benton shales form a rather strong belt striking approximately north-south, it is possible that the shales in some other part of the belt might be of more desirable quality than those whose tests were given above.

PASSBURG, ALBERTA.

In a previous report on the shale deposits of the western provinces,[1] attention was called to a number of shale beds, interstratified with sandstones, which outcropped along the Canadian Pacific railway between Lundbreck and Burmis, most of which were red burning, but not in deposits of large size. These were classed at the time as Edmonton, although later determinations by members of the Survey seem to place them as Upper Cretaceous.

[1]Ries and Keele, Can. Geol. Surv., Mem. 24, p. 95.

In the season of 1913, more or less quiet prospecting has been done in the region east of the Crowsnest pass. This was occasioned partly by the reported discovery of high-grade clays on the South Fork and probably also by inquiries received from some of the clayworking establishments near Calgary.

Among the deposits that have been prospected is one located near Passburg, in sec. 11, tp. 7, range 3, W. 5th mer. The claim which is controlled by J. Kerr, of Passburg, and others, is about 200 feet from the Oldman river, about one-half mile south of the Canadian Pacific Railway track, and 2 miles west of Burmis station. The deposit is covered somewhat by the river terrace deposits, but the beds which are somewhat folded are of Blairmore (Dakota ?) age, according to Leach's map of 1912.

Six samples were supplied from different beds by Mr. Kerr as follows:

Lab. sample 1936, Kerr's No. 4, said to represent a 5-foot bed, the highest of the section.

Lab. sample 1939, Kerr's No. 3, from a 4-foot bed.

Lab. sample 1921, Kerr's No. 1, from a 4-foot bed.

Lab. sample 1920, from 8-foot bed about same level as 1921.

Lab. sample 1938, Kerr's No. 5, said to be 4 feet thick, and to lie 20 feet below 1921.

Lab. sample 1937, Kerr's No. 6, said to lie 15 feet below No. 5, and to be 10 to 12 feet thick.

The deposit was more extensively opened up after the writer's visit to the region, and four of the samples were sent in later.

The following are the laboratory tests made on the samples, and conclusions drawn from them.

One sample (Lab. No. 1936) was a soft grey shale, that works up well to a plastic mass and could be made to flow through an annular die. The average air shrinkage was 8·7 per cent, which was a little high. It burns to a red colour, and is thoroughly vitrified at cone 1, in fact the bricklets deformed under the weight of a few courses of test bricklets resting on them. Fired at several cones the following results were obtained:

Laboratory Sample No. 1936.

Cone	Fire shrinkage %	Absorption %
010	1	10·00
05	3	7·43
1	5·4	0·09

The shale shows a low fire shrinkage, and the bricklets had a good ring even when burned only to cone 010. It will not stand burning above cone 1, or even that high, but at cone 03 should give a good dense brick. The absorption is not high even at the lowest cone at which it was tested. The material would probably make a vitrified product at a low cone. Figure 13 gives the graph of the burning tests.

A second sample (Lab. No. 1939) was a silty clay shale, which, however, has good plasticity, and worked up well to a plastic mass whose air shrinkage was 7 per cent. The shale burned pink at cone 010, red at cone 05, and brown at cone 1. It became steel hard at cone 05, but the bricklets had a good ring even at cone 010. The clay was vitrified and even somewhat softened at cone 1. It fused about cone 3.

Below are the burning tests:

Laboratory Sample No. 1939.

Cone	Fire shrinkage %	Absorption %
010	0	11·00
05	1·8	8·50
1	5·0	1·59
3	Fused	

From the tests on the wet-moulded bricklets the clay gives evidence of making a vitrified ware at a low cone. The graphs of the wet-moulded tests are shown in Figure 14.

Dry-press bricklets burned at cone 010 were too soft, but those fired at cone 05 had a good ring and 10·88 per cent absorption.

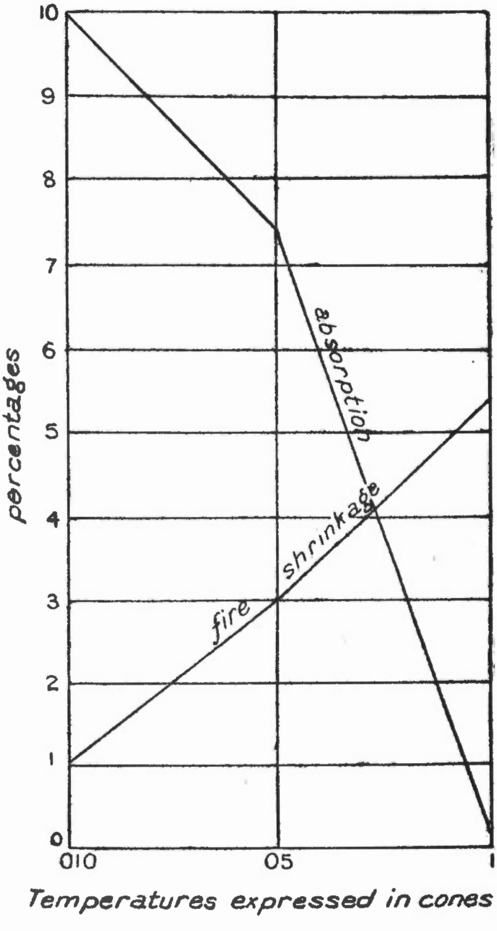


Figure 13. Shrinkage and absorption curves of shale, Laboratory Sample No. 1936, Passburg, Alberta.

A third sample (Lab. No. 1921) was a light grey shale, which when ground up and mixed with water gave a body of excellent plasticity whose average air shrinkage was 6·6 per cent, and average tensile strength when air-dried was 30 pounds per square inch. No difficulty was experienced in forming

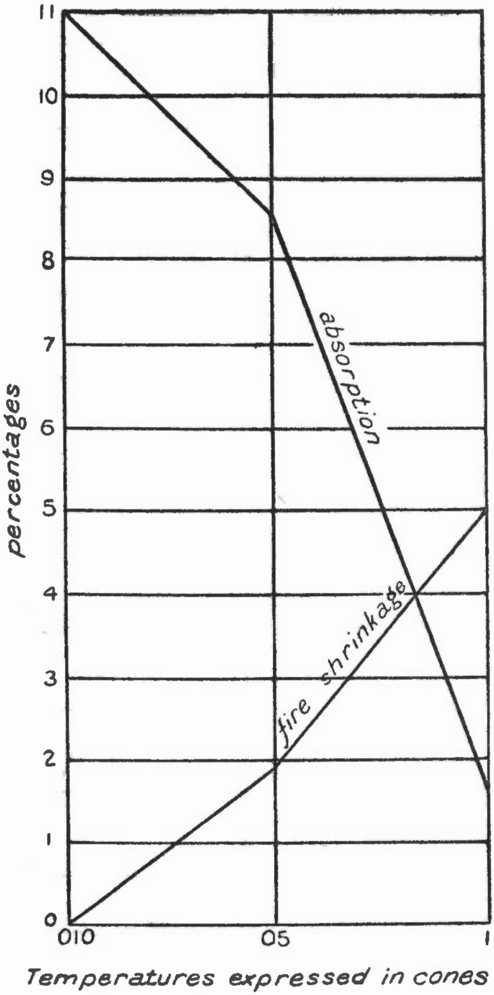


Figure 14 .Shrinkage and absorption curves of shale, Laboratory Sample No. 1939, Passburg, Alberta.

wet-moulded bricklets of the clay, nor in making it flow through an annular die. The bricklets had a good ring even at as low a cone as 010.

The burning tests were as follows:

Laboratory Sample No. 1921.

Cone	Fire shrinkage %	Absorption %	Colour
010	1·6	11·46	salmon
05	4·2	6·18	red
1	5·4	2·00	dark red
3	Fused		

The shale softened somewhat even at cone 1, and it would hardly be safe to burn it as high as this, if used alone. The fire shrinkage is not high, and neither is the absorption.

Figure 15 shows graphically the burning tests.

The clay could probably be moulded dry-press.

Several possible uses suggest themselves. The shale could be employed for making red brick, and possibly vitrified brick. It could also be moulded and burned at a low heat for drain tile. If the shale will take a salt glaze it should be tried for sewer-pipe. Fireproofing is another product that I believe could be made from this shale.

A fourth sample (Lab. No. 1920) is also a light grey shale of good plasticity, which worked up readily with 21 per cent of water. The average air shrinkage was 6·6 per cent, and the average tensile strength when air dried was 25 pounds per square inch. It had enough plasticity to flow through a tile die. The shale burns to a red colour, which increases in depth with the intensity of the firing. The bricklets are steel hard at cone 05, and practically vitrified at cone 1. The burning tests were as follows:

Laboratory Sample No. 1920.

Cone	Fire shrinkage %	Absorption %
010	1·0	9·02
05	2·7	7·75
1	4·7	2·30
3	fused	

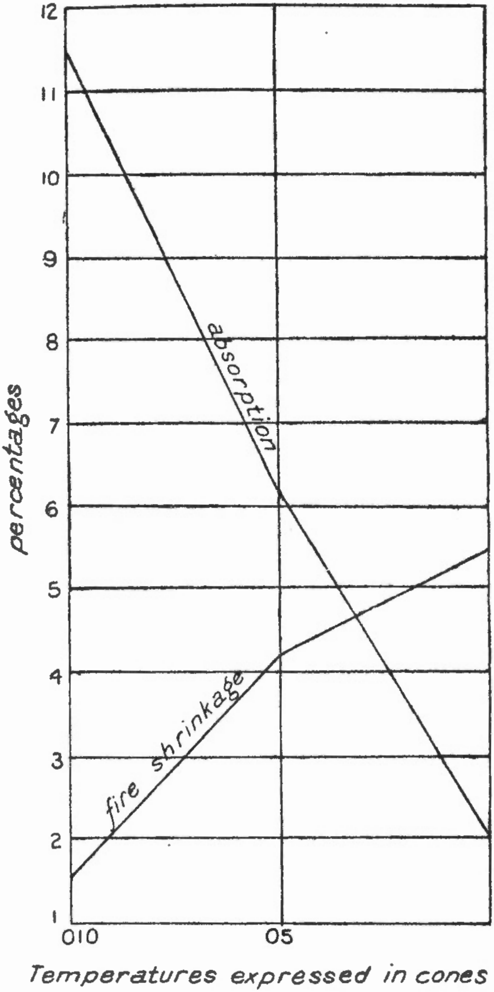


Figure 15. Shrinkage and absorption curves of shale, Laboratory Sample No. 1921, Passburg, Alberta.

These tests are shown graphically in Figure 16.

The shale would probably work for paving brick, as well as building brick.

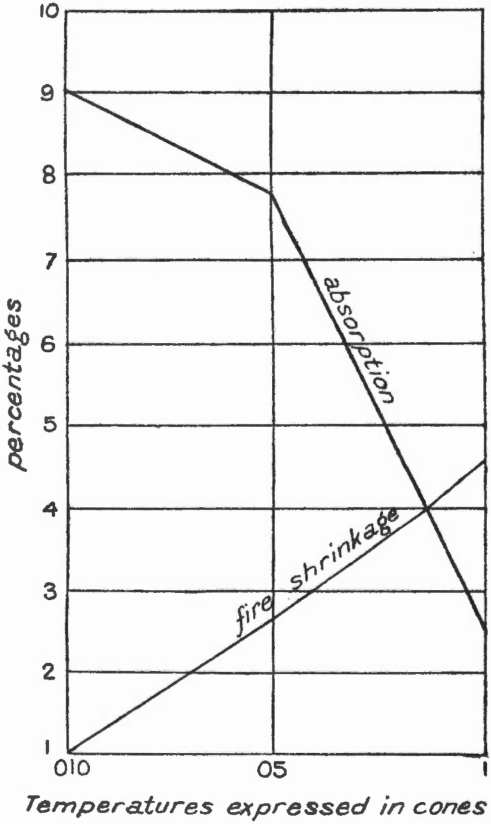


Figure 16. Shrinkage and absorption curves of shale, Laboratory Sample No. 1920, Passburg, Alberta.

A fifth sample (Lab. No. 1938) is another shale of good plasticity, whose air shrinkage was 8·5 per cent. The shale burns to a brownish red colour and is steel hard at cone 05. The burning tests were as follows:

Laboratory Sample No. 1938.

Cone	Fire shrinkage %	Absorption %
010	1·0	11·98
05	1·7	9·24
1	3·6	4·16
3	5·0	3·40
7	nearly viscous	

Figure 17 shows the above graphically.

This is one of the most refractory of the Passburg shales tested, and in this respect resembles the next one. The bricklets had a good ring and colour even at cone 010.

The dry-press bricklets at cone 010 showed 12·58 per cent absorption, and 2·6 per cent fire shrinkage. They were a little soft for use. Those burned at cone 05 were nearly steel hard, with 11·07 per cent absorption.

A sixth sample (Lab. No. 1937) is of a clay shale which is sandy and of low plasticity. It does not work as well as 1936 for example, and yet no trouble was experienced in wet-moulding it, nor in forming it into dry-press bricklets. The average air shrinkage of the wet-moulded shale was 7 per cent. It burns to a red body, which is steel hard at cone 05. The absorption is moderate, and the fire shrinkage is low up to cone 05. These facts were borne out by the following tests of the wet-moulded bricklets:

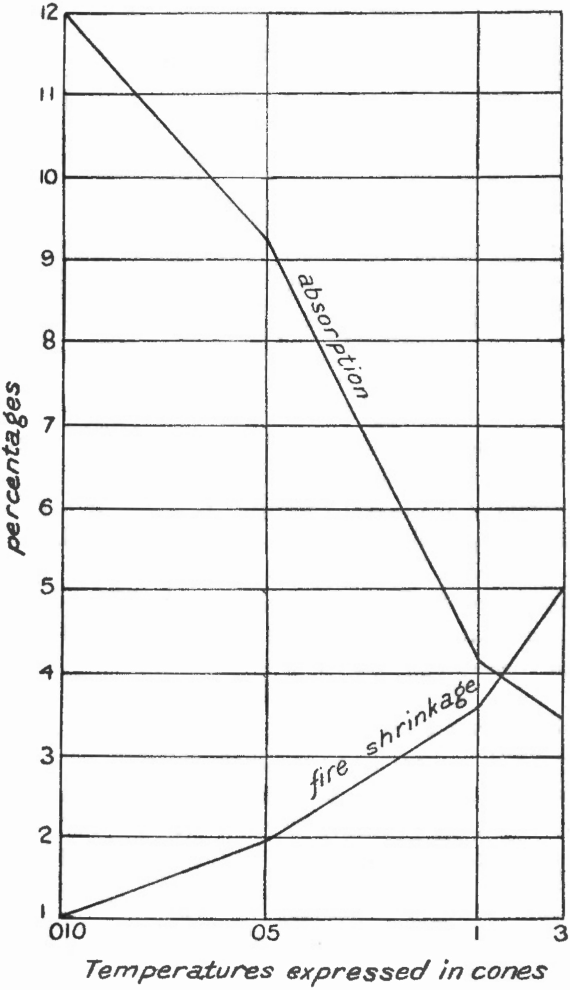


Figure 17. Shrinkage and absorption curves of shale, Laboratory Sample No. 1938, Passburg, Alberta.

Laboratory Sample No. 1937.

Cone	Fire shrinkage %	Absorption %
010	1·3	15·91
05	2·0	14·20
1	6·0	2·93
3	8·0	1·50
7	viscous	

The dry-press bricklets were too soft for use at cones 010 and even 05, but at cone 1, they were hard, with a fire shrinkage of 7·6 per cent and an absorption of 3·3 per cent.

Comments on Passburg Shales.

The tests made on the shales from Passburg are interesting. They are all plastic. Four of them soften at a comparatively low cone, while the other two stand a much higher heat. It seems that the best plan to adopt would be to make a mixture of the two classes, as the shales of higher heat resistance would serve to hold the mixture up in burning.

I believe that the shales contain good possibilities. Most of the shales are sufficiently plastic to flow through a die. They burn to a good red dense body, with low shrinkage and low absorption. Those of lower fusibility could be used for common or pressed brick, drain tile, or, I believe, for fireproofing. A mixture of the two classes of material could probably be used for paving brick, and possibly sewer-pipe. In the latter case, the more refractory of the shales should form two-thirds of the mixture.

SOUTH FORK, ALBERTA.

In the report covering the field season of 1912, a number of tests were given of some clays obtained by Mr. J. D. Mackenzie of the Geological Survey, from near Jackson creek, a branch of the South Fork river, in the NE. ¼ sec. 23, tp. 6, range 3, W. 5th mer. These clays according to Mackenzie,

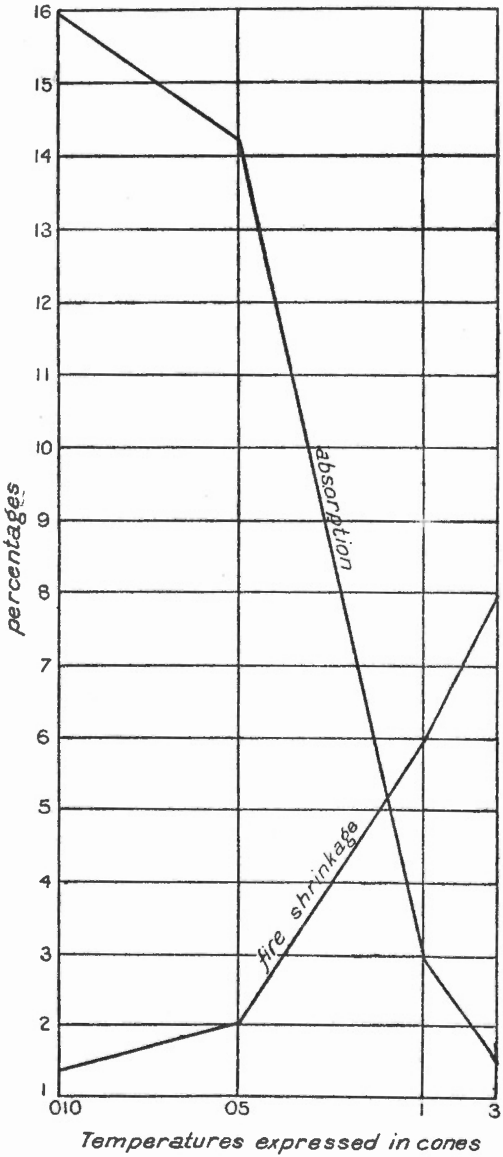


Figure 18.—Shrinkage and absorption curves of shale, Laboratory Sample No. 1937, Passburg, Alberta.

lie in the Benton, and are folded into an overthrown syncline, the underlying volcanics being well exposed (Plate VIII A) both up and down stream from the shales. The clay occurs in beds from 4 to 8 feet thick, interbedded with dark carbonaceous shales. The shales show considerable disturbance, as a result of which the clay beds pinch and swell. A small stream cuts across the strike of syncline, and it is on the sides of the small valley made by it that the prospecting for clay has been done. Owing to a heavy covering of stream gravel which appears first on one and then the other side of the gulch, exploration for the clay has been rendered somewhat difficult.

Following up this small tributary valley, one comes first to the volcanics which form the lower limb of the syncline (Plate VIII A). These are very gritty and of no value for the manufacture of clay product. At one point a stream of spring water has trickled down over the volcanic rock, and decomposed it, so that a thin layer of clayey material can be scraped off, but there is not enough of it to be of any value.

Following up the valley a few hundred yards, the west side is gravel covered, while the east side is uncovered. Here, three openings have been made on the hillside. The lower opening is near the stream level, and shows the greyish clay, with a hanging-wall of dark shale. The material (Plate VIII B) appears to be slightly faulted. A second opening lies about 50 feet up the hill side and west of south from the lower pit. A third opening has been made at about the same level as the second, but north of east from the first or lower one. The bed exposed in the second opening appears to dip towards the first and the two may belong to the same bed. In both the second and third openings there is a hanging-wall of dark shale, and in the third opening the foot-wall is also seen, showing a thickness of not over 8 feet, with the beds dipping northwest.

The western or second pit is represented by Lab. No. 1925 and the third pit by Lab. No. 1929. In each case the samples were taken by sectioning across the bed of clay. The clay in the second pit had some scattered nodules of lime carbonate.

A few hundred feet farther up the stream, the shales form a steep outcrop on the western side of the bank. Here the strike is N. 60 degrees W., and the dip about 65 degrees N. A cut about 18 feet high has been made exposing the clay which is of irregular thickness and confined between walls of carbonaceous shale.

Just across the stream from this outcrop there is a low bench of soil and dirt, and then the gravel bank rises steeply to the rim of the valley. Several test pits and other holes have been put into the gravel bank, in an effort to pick up the clay along its line of strike on the east side of the valley, but at the time of my visit none of these had penetrated through the gravel.

The first factor to be considered here is the location of the deposit and its possible structure. The variation in thickness seen in the cut farthest upstream and the disturbed nature of the clay in the lowest of the group of three openings justify the belief that the clay beds may be rather irregular in their thickness. The fact that the shales containing the clay are bent into a syncline, of probably no great size, speaks for a limited depth on the dip. These facts coupled with the narrowness of the beds do not argue for a large supply, sufficient to support an extensive plant. How far the clay extends on the strike is not known, as outcrops are scarce.

The clay would have to be worked entirely by underground methods, such as drifts run along the strike, or as the owners suggest, by a tunnel at right angles to the strike, from the valley below. This tunnel would probably strike the clay low down in the syncline.

The two samples collected were carefully tested, to form some definite idea of their value.

Sample No. 1929 was a yellowish grey clay, of calcareous character which worked up to a moderately plastic mass with 30 per cent of water. The average air shrinkage was 8 per cent and the average tensile strength 35 pounds per square inch.

Wet-moulded bricklets were made to determine the shrinkage and absorption in burning, with the results shown following:

Laboratory Sample No. 1929.

Cone	Fire shrinkage %	Absorption %	Colour
010	0·3	17·88	buff
05	1·3	14·00	buff
1	4·0	9·72	buff
3	5·0	9·8	buff

The wet-moulded bricklets were steel hard at cone 05. The brick burned at cone 010 and had a good ring; but since those tested from this locality last year air slaked after burning at this cone, the present ones were carefully watched. They were first dried on a radiator for 24 hours, and then placed in water for another 24 hours without showing any signs of disintegrating. While the clay burned buff up to cone 3, it turned bluish grey above that, or even at cone 1 if burned in a reducing fire.

Dry-press bricklets were also tried. One burned at cone 010 was speckled pink, had a fire shrinkage of 3 per cent, and an absorption of 15·97 per cent. A second dry-press sample fired at cone 05, showed 4·5 per cent fire shrinkage, and 9·7 per cent absorption. The body was buff in colour, and steel hard. The surface of the brick was not very smooth, due to granular fusible impurities.

Clay No. 1925 was similar in appearance to 1929, showing the same granular character, and being slightly more calcareous. It yielded a very plastic mass with 28 per cent of water. The average air shrinkage was 6·9 per cent, and the average tensile strength 50 pounds per square inch.

The clay burns buff up to cone 1, unless exposed to a reducing fire, when it turns grey. It became steel hard at cone 05, but should not be burned at a lower cone, such as cone 010, because of its tendency to air slake. The bricklets fired at 010 disintegrated almost completely after standing in the laboratory for about a week. If burned harder the body is sufficiently bonded by vitrification to prevent disintegration, and moreover the lime fluxes in part with the surrounding particles of the clay.

Tests on the bricklets are given below:

Laboratory Sample No. 1925.

Cone	Fire shrinkage %	Absorption %	Colour
010	0·0	——	buff
05	0·6	19·48	buff
1	1·3	15·62	buff
7	Fused		

Dry-press bricklets fired at cone 1 in slightly reducing fire, had a fire shrinkage of 0·7 per cent, absorption of 13·70 per cent, and grey colour.

Both these clays could be used for making buff or blue-grey pressed brick, but it is questionable whether they would be of much use for other kinds of burned clay wares. I cannot regard them as of value for pottery since much better pottery clays are to be obtained elsewhere in the western provinces.

The deposits are somewhat remotely located from the railway, but one could be constructed into this district without serious difficulty.

JASPER PARK, ALBERTA.

In last year's report a description was given of a cream-burning, calcareous lake clay that was found at the coal mines at Pocahontas, Alberta. This year a sample of similar material was sent in by G. Conway Brown, from the same district.

The clay is very plastic, but typical of clays containing a large quantity of lime carbonate, and is not a fireclay. It has an air shrinkage of 7·5 per cent and burns to a cream-coloured brick, of high absorption. At cone 010 the fire shrinkage was zero, and the absorption 28·20 per cent. At cone 05, it still had zero fire shrinkage, and an absorption of 27·61 per cent. At cone 1, the fire shrinkage was 2·7 per cent, and absorption 27·60 per cent. At cone 3, the clay was nearly viscous.

The clay could be used for making common brick, and possibly even drain tile, although the latter, of course, could not be vitrified. In its general characters it resembles many of the calcareous brick clays used in Manitoba.[1]

COCHRANE, ALBERTA.

A sample of very plastic clay was sent to the Geological Survey by Dr. T. G. Ritchie of Cochrane. It was found on the SE. ¼ tp. 26, range 4, W. 5th mer. Nothing is known regarding the extent of the deposit.

The material (Lab. No. 1948) is a dark grey calcareous clay, that worked up to a mass of excellent plasticity with 19 per cent of water. The average air shrinkage was 7 per cent, and the average tensile strength 155 pounds per square inch when air dried. The clay flows well through a tile die. The burning tests on the wet-moulded bricklets were as follows:

Laboratory Sample No. 1948.

Cone	Fire shrinkage %	Absorption %
010	0·45	18·70
05	0·85	18·10
1	4·00	2·65
3	Nearly fused	

The clay although calcareous is not sufficiently so to yield a buff or cream colour after burning, and there is enough iron as compared with lime to colour it red.

The material is to be classed as a brick and tile clay. It could probably be worked dry-press if burned hard enough. The bricks would be too porous if burned at a low cone.

[1]See Ries and Keele, Can. Geol. Surv., Memoir 24 E, p. 18 et. seq. 1912

SUMMARY OF TESTS ON WET-MOULDED BRICKLETS.

Laboratory Number	Locality.	Water required per cent	Air shrink. per cent	Tensile strength lbs per sq in	010 Fire shrink.	010 Absorption.	05 Fire shrink.	05 Absorption.	1 Fire shrink.	1 Absorption.	3 Fire shrink.	3 Absorption.	5 Fire shrink.	5 Absorption.	9 Fire shrink.	9 Absorption.	15 Fire shrink.	15 Absorption.	Colour.	Recommended for and remarks.
1942	Red shale, Blue mountain, B.C.	18	5	25	1	17·20	2	16·07	3	13·63	4	6·90	5	1·28	Viscous				Red	Common brick. Face brick. Quarry tile. Works dry press.
1943	Blue shale, " " "	25	8	25	2·8	17·60	4·4	15·55	5·6	10·35			7*	7·0*	7·4	5·1	11·5	2·6	Buff	Pressed brick. Fire brick. Terra-cotta. Fuses cone 30.
1944	Grey " " " "	29	8·5	25	3·0	13·72	3·3	11·25	5·4	9·28	6·5	6·63	7	5·5	8·0	3·8	8·6	1·2	Deep buff	Pressed brick. Works dry press. Possibly sewer-pipe.
1943 and 44	Mixture " " "		6·6	35	3·0	12·50	4·4	11·25	5·0	11·43	6·0	10·50	6*	9·25*	6·4	9·0	7·3	4·0	" "	Brick. Fireproofing.
1942 and 44	" " " "		5·6				5·4†	9·0†	5·4	9·0	5·4	9·0	6	7·6	7·0	6·0			Red	Face brick. Fireproofing.
1945	White clay, " " "	18	5	25	3·3	14·25	4·0	14·18	6·0	10·40			9·4	4·65	9·0	4·6	9·6	2·2	Cream	Face brick. Terra-cotta. Can be dry-pressed.
1928	Buff weathered shale, Gabriola island	22	7·6		1·4	13·43	4·4	9·18	7·4	0·78	Nearly fused								Red	Dry pressed brick.
1927	Blue, unweathered shale, " "	18	5·0		0·6	12·54	4·0	12·07	6·0	2·49	5·0	3·0							Red	(Dry pressed brick.)
1933	West of Mudge is., near Nanaimo, B.C.	The shale cannot be wet moulded. Can be dry pressed, but not very satisfactory.																	Red	
1931	Top clay, Empire coal mine, Princeton, B.C.	29	9·3	96	1·7	16·76	4·1	13·25	6·3	9·04	7·4	7·85	7·4	3·2		0·9	Nearly fused			Pressed brick.
1919	Preheated clay cut near Cement mill, Princeton, B.C.		7		1	17·10	3·3	10·20	7	6·10									Red	Can be used for red brick if preheated.
1950	Same locality, mixture 25% raw clay and 75% calcined clay		8		1·85	16·58	2·4	11·76	6·6	4·92									Red	(Can be used for red brick if preheated.)
1951	Same locality. Equal parts calcined and raw clay		6·5	81	2·0	18·16	3·3	16·80	8·3	5·52									Red	(Can be used for red brick if preheated.)
1934	Clay under upper coal, Princeton Coal and Coke Co., Princeton, B.C.	25	5·0		0·6	25·15	2·0	25·50	4·0	19·36			5·0	18·80	6	16·80	Fused		Buff	Tests made on preheated clay.
1932	Clay under lower coal same place	Cracked badly after preheating to 300°C.																		
1935	Hanson brickyard, Cranbrook, B.C.	20	5·4	87	0	26·43	1	20·80	10·7	0·10	Fused								Red	Brick and tile. Will dry press.
1941	Schist, Wyckliffe, B.C.	Plasticity too low to mould. Difficult to make cohere in dry pressing.																		
1946	St. Mary river, 4 miles above Ste. Eugene Mission	29	4·2	57	2	27·6	5	25	11	8·8	13	0							Pink	
1930	1 mile northeast Canyon, B.C.	23·8	3·1	25	0	18·6	1	16·2	9·4	4·76	9·5	4·7	Nearly viscous cone 7.						Pink	
1924	Goat Canyon station, B.C.	30·8	4·9	45	0	25·8	0	24·0	10·3	0·0									Pink	Common brick.
1923	Between Creston and Goat canyon, B.C.	35	7	90	0	26·4	1·5	23·50	1·7	16·87	Fused								Red	Common brick and tile.
1940	2 miles west of Coleman, black shale	Does not work plastic. Can be dry pressed.																	Red	
1922	" " shale	Difficult to dry press. No plasticity.																		
1926	" shale near waterfall	22	4·3	20	0·8	18·20	1	15·12	1·4	14·73									Red	
1949	Mixture of 1926 and 1940	14	4	25	0·5	15	1	14·10	1	11·12									Red	Will dry press also.
1936	Passburg, Alberta	25	8·7		1	10	3	7·43	5·4	0·09	Nearly fused.								Red	Vitrified brick.
1939	" "	23	7		0	11	1·8	8·5	5	1·59	" "								Red	" "
1921	" "	22	6·6	30	1·6	11·46	4·2	6·18	5·4	2·0	" "								Red	Red brick; draintile; fireproofing.
1920	" "	21	6·6	25	1·0	9·02	2·7	7·75	4·7	2·3	" "								Red	Paving brick.
1938	" "		8·5		1	11·98	1·7	9·24	3·6	4·16	5	3·40	Nearly fused at cone		7				Red	Will dry press.
1937	" "		7		1·3	15·91	2	14·2	6	2·93	8	1·5	" " " "						Red	
1929	South Fork, southeast of Blairmore	30	8	35	0·3	17·88	1·3	14	4·0	9·72	5	9·8							Buff	Face brick.
1925	" " "	28	6·9	50	0·0		0·6	19·48	1·3	15·62			Fused at cone		7				Buff	" "
1948	Cochrane, Alberta	19	7	155	0·45	18·7	0·85	18·1	4·0	2·65	Nearly fused								Red	Brick and tile.
1947	Pocahontas, Alberta	25	7·5		0	28·20	0	27·61	2·7	27·60	" "								Cream	
1953	Giscombe Portage, B.C., 30 miles above Fort George, on Fraser river.	20	6		2·3*	17·10	3	15·4	3·0	15·5			5·0	10·2	6·0	8·1			Cream	Face brick and firebrick.
11904	(Giscombe Portage, B.C.)	15	4		1*	14·0	1	14·0	1·5	13·5			2·5	11·0	2·5	9·5			Cream	(Face brick and firebrick.)

†Cone 07; *Cone 7

EXPLANATION OF PLATE I.

Gravity plane and chutes, Kilgard, B.C.

PLATE I.

EXPLANATION OF PLATE II.

A. North end of shale bank, Dominion Brick and Tile company, Gabriola island near Nanaimo, B.C. Note the sandstone bed in shale.

B. Shale bank showing sandstone layers which have to be thrown out in quarrying the shale, Gabriola island, B.C.

PLATE II.

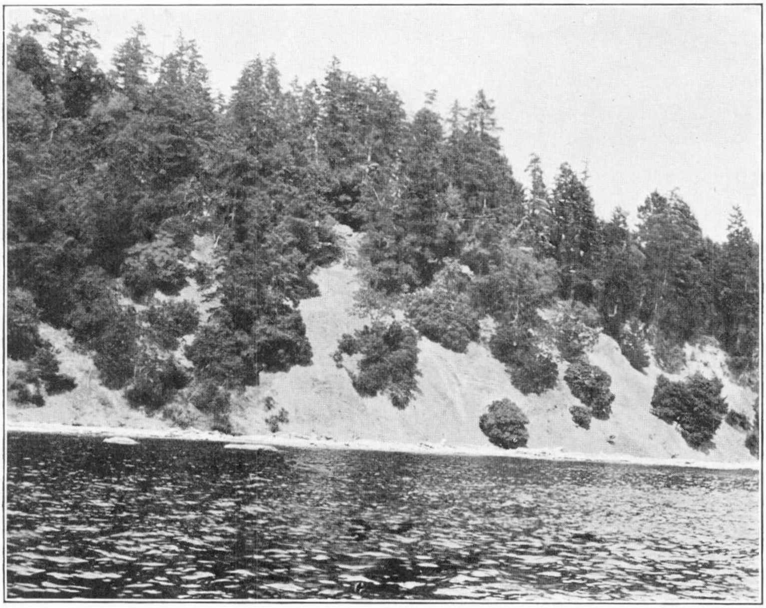
A

B

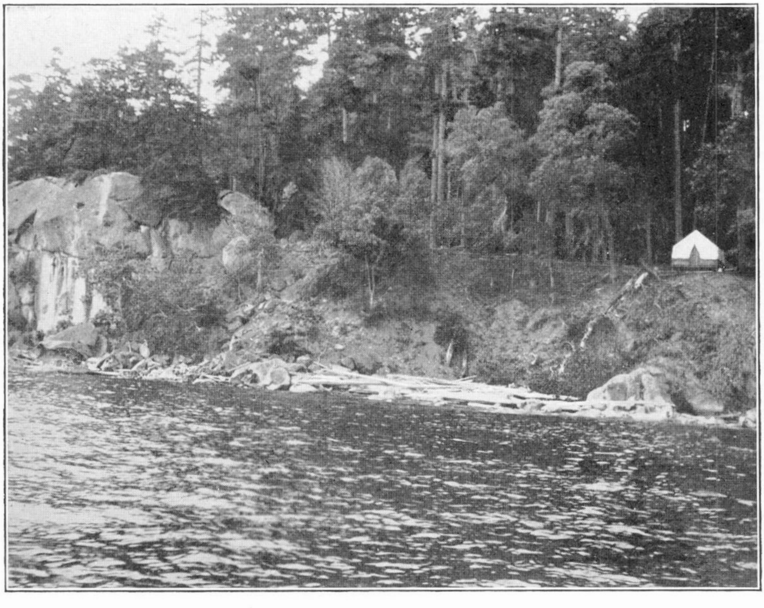
EXPLANATION OF PLATE III.

A. Shale bank on the south shore of Mudge island near Nanaimo, B.C.

B. Sandstone outcropping just west of shale shown in A.



A

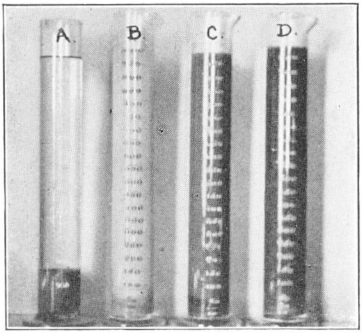


B

Explanation of Plate IV.

View of jars containing suspended clay after standing twenty days.

PLATE IV.



EXPLANATION OF PLATE V.

A. General view of Hanson's brickyard near Cranbrook, B.C.

B. Clay pit at Hanson's brickyard near Cranbrook, B.C.

PLATE V.

A

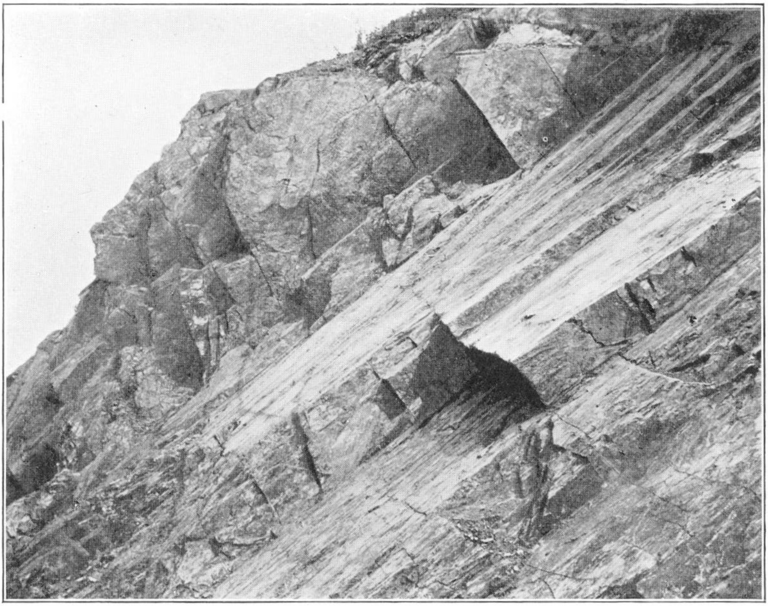
B

EXPLANATION OF PLATE VI.

A. Pre-Cambrian metargillite along the track at Wyckliffe, B.C.

B. Clay cut at Goat canyon near Creston, B.C., on Canadian Pacific railway.

PLATE VI.



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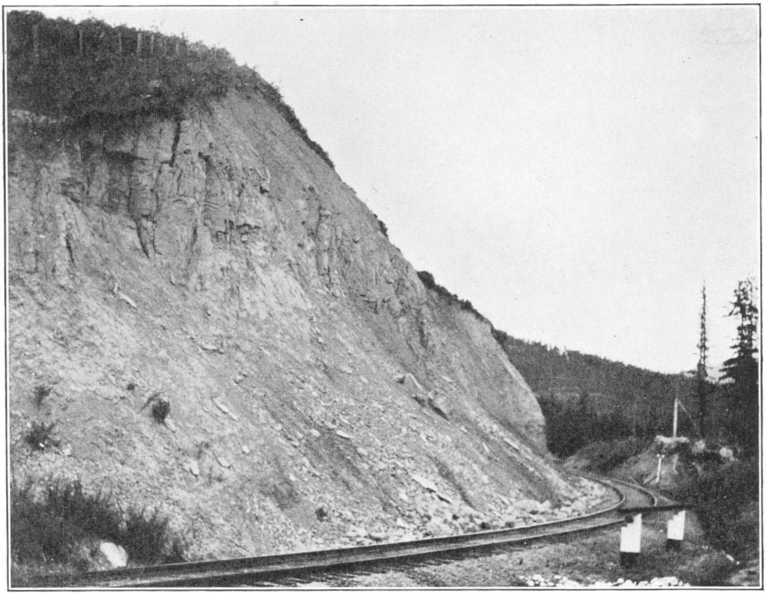

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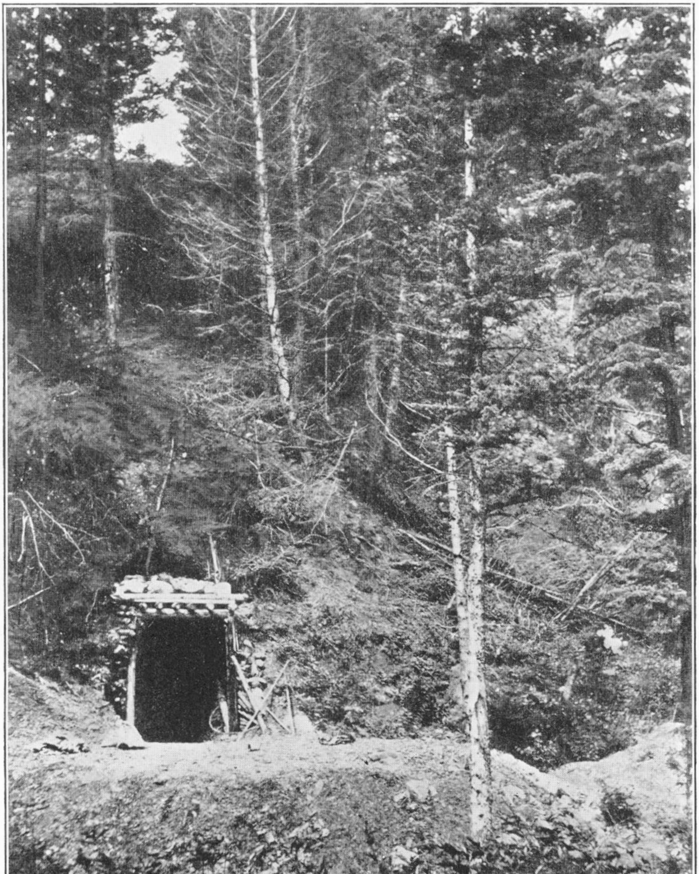
EXPLANATION OF PLATE VII.

Shale bank and tunnel on G. H. Bradley's claim, 2 miles west of Coleman, Alberta.

PLATE VII.



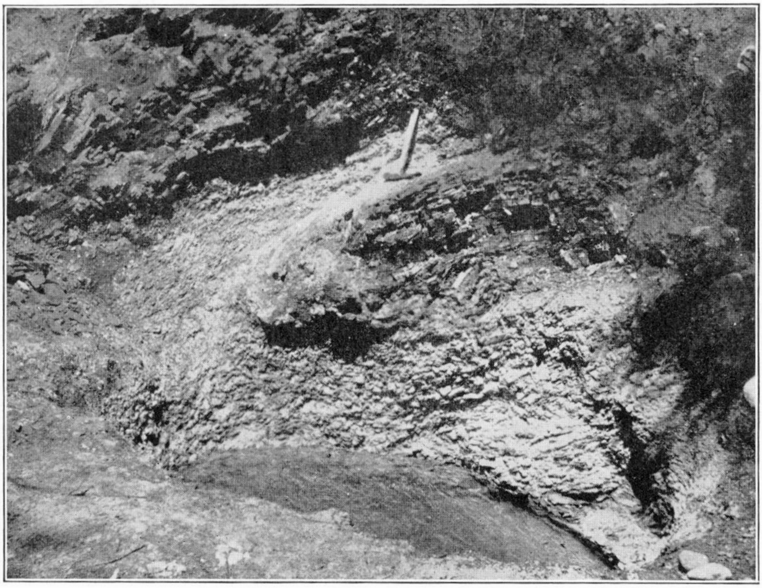
Explanation of Plate VIII.

A. View showing volcanics forming lower limb of overthrown syncline near South Fork. The Benton shales with grey clays underlie the ridge at rear.

B. Test pit along creek tributary to South Fork, on claims of Buckler and Diver. Light material is clay; dark rock is carbonaceous shale. There is probably a slight fault here.

PLATE VIII.

A



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