CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN McLEISH, DIRECTOR

INVESTIGATIONS

IN

CERAMICS AND ROAD MATERIALS

(Testing and Research Laboratories)

1924

OTTAWA
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Annual reports on Mines Branch investigations are now issued in four parts, as follows:—

Investigations of Mineral Resources and the Mining Industry.

Investigations in Ore Dressing and Metallurgy (Testing and Research Laboratories).

Investigations of Fuels and Fuel Testing (Testing and Research Laboratories).

Investigations in Ceramics and Road Materials (Testing and Research Laboratories).

Other reports on Special Investigations are issued as completed.

MINES BRANCH INVESTIGATIONS IN

CERAMICS AND ROAD MATERIALS, 1924

INTRODUCTORY

Howells Fréchette

Chief of Ceramics and Road Materials Division

During July, August, and September, the writer visited many of the clayworking plants in eastern Canada, studying their activities and problems.

Mr. L. P. Collin, Ceramic Engineer, conducted an investigation of the cost of burning brick under various conditions. Detailed work was done at fourteen plants in Ontario and Quebec. Incidental to this a number of problems associated with brick burning were studied. The manufacturers welcomed the work and co-operated by furnishing such data as they had available. Suggestions were made at several plants which, if carried out, should result in considerable savings in the cost of manufacture, or in improving the quality of the products. It was found, in a great many cases, that cost accounting had been neglected, either completely or else not carried to sufficient detail. Continuous records of the cost of the various operations contributing to the total cost of manufacture would provide manufacturers with much useful information and would indicate the cause for otherwise unexplainable fluctuations in cost of production, and would frequently point to possible savings that might be effected.

The usual testing of clays, along with other laboratory investigations, was carried on in the ceramic laboratories during the winter months, as reported in Section II.

Mr. R. H. Picher, Road Materials Engineer, continued the investigation of road materials in Nova Scotia and New Brunswick.

The following changes in staff took place during 1924:—

Mr. Henri Gauthier, Road Materials Engineer, resigned August 31st. The position has not been re-filled.

Miss E. M. Campbell, Senior Laboratory Assistant, resigned October 28th, and Miss I. L. McLeish was transferred December 1st, from the office of the Director to fill the vacancy.

I

INVESTIGATION OF CERAMIC INDUS

Howells Fréchette

The tour of inspection of clayworking plants, begun . completed during the summer of 1924. Sections of Ontario not previously covered, were visited, as well as all of the work of the idle plants in New Brunswick, Nova Scotia, and Prir Island.

The visits were for the purpose of studying existing con ascertaining in what way the activities of the Division might so as best to aid and advance the clayworking industry.

The labour troubles in the coal-mining areas have affected t for building materials in Nova Scotia, resulting in a decrease in of building brick. The production of firebrick was also curtai closing of the steel plants in the early summer.

The following manufacturers operated, most of them only time during the summer and none to full capacity:—

Nova Scotia

Avonport Brick Works, Avonport; brick, structural and field
Miller, Jas. B., Barney Brook; brick.
Fairview Clay Works, Fairview; flower pots, etc.
Nova Scotia Clay Works, Ltd., Lantz Siding; brick.
Nova Scotia Clay Works, Ltd., Pugwash; brick.
Standard Clay Products, Ltd., New Glasgow; sewer pipe, etc.
Brooks, Stephen, New Glasgow; brick and firebrick.
Joyce, F. R., Middleton; flower pots.
Brooks, Geo., Plymouth; brick.
B. E. Steel Corporation, Sydney; firebrick.

Prince Edward Island

Prince Edward Island Brick and Tile Co., Ltd., Richmond; brick and field tile. (Operated by Provincial Dept. of Agriculture).

New Brunswick

Tondreau, Jos., Bathurst West; brick.
Roy, A. C., Campbellton; brick.
Ryan and Son, Fredericton; brick.
Northampton Brick Co., Ltd., Grafton; brick.
Loggie (W.S.) Co., Ltd., Nelson; brick.
Charlotte County Cottage Craft, St. Andrews; art pottery.
Foley Pottery, Ltd., St. John; pottery and firebrick.
Stephen Brick Co., Ltd., St. John; brick.
Hartford (Percy) Brick Co., St. Stephen; brick.

In Quebec there was a slight falling off in the demand for structural claywares, and in Ontario the decline was even more pronounced.

In the western provinces, building prospects are still quite uncertain. British Columbia and Saskatchewan produced more brick in 1924 than in 1923, but the other two provinces show a decline in production.

II

LABORATORY INVESTIGATIONS

During the year ninety-two samples of clay and shale were tested to determine their suitability for ceramic purposes. These samples were submitted for testing by officers of the Department of Mines, the Quebec Bureau of Mines, the investigational officers of the Canadian National Railway and the Canadian Pacific Railway, and by individuals.

Below are given the results of the tests on some of the clays best suited for ceramic use and some of those which furnish data on the raw materials in areas not previously covered.

British Columbia

Three samples collected by V. Dolmage of the Geological Survey, three miles from the railway at Williams Lake, when tested gave the following results:—

Sample 1 was a yellow earthy material. It possessed almost no plasticity. Dry-pressed briquettes burned to 2000°F. were very friable. It fused at cone 26 (3000°F.). Owing to its lack of plasticity, it would be of little use for ceramic purposes unless mixed with a refractory bonding clay for the making of medium heat duty firebrick.

Sample 2 was cream coloured, very gritty and only slightly plastic when tempered with 26 per cent of water. Moulded briquettes showed a drying shrinkage of 3 per cent and when burned to 2000°F. were very soft and quite porous. It is probable that a good bond would be formed at a somewhat higher temperature. As this clay does not deform until cone 28 (3074°F.) is reached, it might be used for making firebrick, preferably mixed with a plastic clay.

Sample 3 consisted of small pieces of rock which, when finely ground, possessed no plasticity. Fragments of these were tested for refractoriness and were found to soften at temperatures ranging from 2678°F. to 3146°F.

A sample of a hard, red shale, said to have been taken from the east bank of the Fraser river, about 4½ miles north of Lytton opposite Stein river, was submitted for testing by Gideon Bower, 25 W. 11th Ave., Vancouver, through V. Dolmage. This shale had no plasticity when tempered with water. Dry-pressed briquettes were made and burned with the following results:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Fire shrinkage	0·3%	0·3%	1·0%
Absorption	11·7%	10·6%	8·4%
Hardness	rather soft	fairly hard	hard
Colour	fair red	reddish buff	dark red

The fusion point was cone 3 (2174°F.). This material could be used for the manufacture of dry-pressed brick and should be burned at about cone 05 (1922°F.), or 04 (1958°F.). In the unburned state the brick would require great care in handling on account of the low bonding power of the shale. The addition of a suitable clay in the course of manufacture would be desirable.

Alberta

During the course of his field work, S. C. Ells of the Mineral Resources Division, collected several samples of clay which he submitted for testing, the results of four of which follow:—

Sample 1, from sec. 17, tp. 91, range 9, W. of 4th meridian, was a light grey clay, rather flabby when tempered with 23 per cent of water. It had a drying shrinkage of 3 per cent. A briquette burned at cone 03 (1994°F.) was fairly hard, buff, and showed a fire shrinkage of only 0·3 per cent. The clay fuses at cone 27 (3038°F.). The high fusion of this material places it in the class of moderate heat duty fireclay; however it is hardly plastic enough to be used alone for firebrick or fireclay shapes.

Sample 2, from sec. 17, tp. 91, range 9, W. of 4th meridian, was a dark grey clay, quite plastic when tempered with 24 per cent of water. Its drying shrinkage averaged 8 per cent. Briquettes when burned to the temperatures indicated gave the following results:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Fire shrinkage	0·7%	2·0%	3·3%
Absorption	13·7%	9·2%	6·0%
Hardness	fairly hard	steel hard	steel hard
Colour	reddish buff	reddish buff	reddish buff
Soundness	sound	sound	sound

The fusion point was cone 7½ (2335°F.).

This clay, having good working qualities and a fairly low shrinkage, as well as the property of burning hard at a low temperature, should make a good wire-cut face brick. The colour is not very common but is fairly pleasing. A better buff could be obtained by burning at a higher temperature. It might also be good material for vitrified products, but more extensive tests on a larger quantity of material would be necessary to determine this.

Sample 3, from Clearwater pit No. 1, sec. 14, tp. 89, range 9, W. of 4th meridian, was light brown in colour and was quite plastic but rather stiff when tempered with 26 per cent of water. The drying shrinkage of briquettes was 6·5 per cent. The results of burning tests are shown below:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Fire shrinkage	0·0%	1·0%	3·7%
Absorption	18·5%	14·1%	10·8%
Hardness	soft	steel hard	steel hard
Colour	pinkish buff	pinkish brown	dark brown
Note	scummed	scummed	scummed

The fusion point was cone 8 (2354°F.).

This clay might be used for common brick or tile, but it would require treatment to prevent scumming if required for face brick.

Sample 4 was collected from the west bank of the Firebag river, 17½ miles from the mouth. It was a pinkish, slightly calcareous clay which worked well when tempered with 33 per cent of water. Its drying shrinkage was 6 per cent. The results of burning tests are shown below:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Fire shrinkage	0·0%	1·7%	6·7%
Absorption	24·5%	19·8%	8·1%
Hardness	soft	steel hard	steel hard
Colour	light buff	reddish	dark red
Note	scummed	scummed	scummed

The fusion point was cone 16 (2642°F.).

This material could be used for the manufacture of building or drain tile and face brick, if treated to prevent scumming. It is also quite likely that it could be used for vitrified products.

Saskatchewan

A sample of white clay submitted by George Downey of Elm Springs, was sandy but was quite plastic when tempered with 20 per cent of water. It fused at cone 28 (3074°F.), and when burned at about 2000°F. was a dirty white. Owing to its high fusion point it might be used for the manufacture of a high heat duty siliceous clay firebrick.

A similar clay was submitted by A. A. Davis, 2274 Lorne St., Regina. Its fusion point was cone 30 (3146°F.).

Quebec

A sample of weathered schist was collected from a cutting on the highway on the north bank of the Matapedia river near Millstream for the purpose of determining whether it was refractory or suitable for the manufacture of pressed face brick. It was found to fuse at cone 6 (2282°F.) and therefore of no value for refractory purposes.

When tempered with 23 per cent of water it developed very little plasticity and was too flabby for making brick. Dry-pressed briquettes were made which when burned gave the following results:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Expansion after burning	0·6%	1·8%	2·4%
Absorption	28·6%	34·1%	36·1%
Hardness	soft	soft	soft
Colour	buff	buff	buff

Briquettes were made up of mixtures of the weathered schist and various percentages of local clay but the results obtained indicated that this material is unsuitable for brickmaking.

New Brunswick

A sample of soft red shale, said to have been taken from near Cherryfield, was submitted by Alex. B. McLeod, Sydney Mines, N.S. When ground and tempered with 20 per cent of water, it was quite plastic and worked very nicely. The drying shrinkage of briquettes averaged 5·3 per cent. The results of burned briquettes were as follows:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Fire shrinkage	0·3%	4·6%	7·3%
Absorption	13·0%	6·6%	1·4%
Hardness	hard	very hard	steel hard
Colour	fairly good red	good red	very dark red
Soundness	sound	sound	sound

Fusion point cone 10 (2426°F.).

This shale would make high-grade wire-cut face brick or could be used for drain or building tile. It possesses a long vitrification range and should, therefore, make good vitrified ware, such as roofing tile and quarry tile.

R. H. Picher of this Division collected two samples of clay at the head of Digdeguash basin, Charlotte county.

Sample 1 was a fine-grained silty clay which was fairly plastic but inclined to be flabby when tempered with 35 per cent of water. Briquettes made from this clay had a drying shrinkage of 7 per cent and gave the following results when burned:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Fire shrinkage	0·0%	2·0%	7·3%
Absorption	20·5%	15·8%	2·7%
Hardness	rather soft	quite hard	steel hard
Colour	buff	salmon	dark red
Note	scummed on edges		

Fused at cone 2 (2138°F.).

This clay might be used for common brick, but due to the short range between the temperature at which the red colour is developed and the point of fusion it would be difficult to burn.

Sample 2 was taken from the same bank, but immediately above sample 1. It was quite plastic and worked well, but was rather stiff when tempered with 35 per cent of water. The drying shrinkage of briquettes averaged 8·7 per cent, and when burned they gave the following results:—

—	Cone 010 1742°F.	Cone 06 1886°F.	Cone 03 1994°F.
Fire shrinkage	0·0%	3·7%	10·3%
Absorption	21·2%	10·4%	not determined
Hardness	fairly hard	hard	steel hard
Colour	buff	light red	dark reddish brown
Note	scummed	scummed	bloated due to carbon core

Fused at cone 2 (2138°F.).

This clay could be used for common brick but the scum and the high carbon content might cause trouble. A mixture of the two clays would make a better product than either of them alone.

Several samples of clay were submitted by face-brick manufacturers for the purpose of determining the amount of soluble salts which they contained and the treatment required to counteract their action and prevent the formation of scum on the bricks.

The transverse and compression strengths and absorption were determined on twenty-two samples of brick and tile.

The facilities and assistance of the Ceramic Laboratories were placed at the disposal of the Air Board and the Department of Marine and Fisheries for special tests, and one of the magnesite-producing companies for experiments in the making of magnesite brick. These experiments were not carried to a conclusion, but the results obtained appear to indicate that sound bricks may be produced from the magnesite of Grenville township, Quebec.

During the year, L. P. Collin spent considerable time on the preliminary work of an investigation on the compounding of ceramic bodies for use in electric-heating devices.

III

INVESTIGATION ON COST OF BURNING BRICK AND TILE. ONTARIO AND QUEBEC

L. P. Collin

With a view to furnishing information to manufacturers of brick and tile by which they could compare their burning efficiencies, an investigation of burning costs was undertaken. The results serve primarily to show the great differences in cost which exist at the present time at various plants and to show manufacturers their relative standing. It should be an incentive, particularly to those whose costs are high, to use every means possible to increase their efficiency in the burning operations.

During the summer fourteen plants were visited, twelve in Ontario and two in Quebec. At each of these plants a careful study was made of the burning. The firing of one or more kilns was observed from start to finish wherever possible. Cost figures representative of a year's average were furnished by the manufacturers. In one or two cases no accurate figures of costs had been kept. At these plants figures on the cost of burning two or three kilns were obtained by direct observation, and were checked as closely as possible by such figures as were available.

In covering fourteen plants in so short a period as three months, it was impossible to obtain complete detailed information concerning the burning processes, but the figures given in the tables may be regarded as fairly reliable.

In accordance with the wish of some of the manufacturers the names of the plants are omitted.

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TABLE I

Data on Burning Brick and Tile

Plant No.	Product	Type of kiln	Average capacity, tons	Maximum temperature °F.	Burning time (hours)		Fuel		Total cost of burning	Remarks
					Periods	Total	Amount per ton of ware	Price at kilns (per ton or cord)		
1	Wire-cut face and common brick (clay).	Up-draft with permanent walls and arches.	520	1800	* w.s. 48 o. 96 s. 72	216	65 lbs. coke 188 lbs. coal	$13.10 10.75	$2.12	Burned ware is 60% face and 40% common brick. Loss about 2%.
2	Pressed face brick (clay and shale).	Round down-draft	431	1850	w.s. 120 o. 50 s. 70	240	·042 cords wood 264 lbs. coal	10.33 5.79	1.76	Approximate loss 2%
3	Pressed face brick (clay and shale).	Rectangular down-draft.	374	1825	w.s. 120 o. 62 s. 82	264	·07 cords wood 313 lbs. coal	10.25 7.55	2.44	Approximate loss of 10%.
4	Building tile (clay)..	Round down-draft	110	1900	w.s. 18 o. 36 s. 12	66	378 lbs. coal	7.02	2.10	Actual loss 4·7%.
5	Soft-mud common brick (clay).	Up-draft with permanent walls and arches.	470	1825	w.s. 120 o. 30 s. 66	216	·002 cords wood 75 lbs. coke 107 lbs. coal	6.00 9.73 6.92	1.69	Estimated loss 1%. Soft brick 20%.
6	Wire-cut face brick (clay and shale).	Round down-draft	169	1950	w.s. 16 o. 64 s. 63	143	252 lbs. coal	9.25	2.04	Loss 2%. 77% brick set are face. 23% brick set are common.
7	Wire-cut common brick, building tile (clay and shale).	Top-fired continuous.	50 per chamber	1800	w.s. 36 o. 44 s. 40	120	94 lbs. coal	7.95	1.00	Loss 4·0%. Burning both common brick and building tile.
8	Wire-cut face brick (clay and shale).	Gas-fired continuous.		1900	w.s. 48 o. 108 s. 84	240	120 lbs. coal	9.00	1.04	Estimated loss 2%.

TABLE I—*Concluded*

Data on Burning Brick and Tile

Plant No.	Product	Type of kiln	Average capacity, tons	Maximum temperature °F.	Burning time (hours): Periods	Burning time (hours): Total	Fuel: Amount per ton of ware	Fuel: Price at kilns (per ton or cord)	Total cost of burning	Remarks
9	Wire-cut common brick (clay and shale).	Top-fired continuous.		Temperature not determined.	w.s. 48 o. 96 s. 72	216	148 lbs. coal	$ 6.58	$ 1.07	Estimated loss 2%.
10	Wire-cut and soft-mud face and common brick (clay).	Round down-draft	206	1875	w.s. 32 o. 20 s. 92	144	·06 cords wood 289 lbs. coal	6.25 6.27	2.21	Estimated loss 1%.
11	Pressed face brick (clay and shale).	Rectangular down-draft.	438	1900	w.s. 120 o. 40 s. 60	220	·05 cords wood 264 lbs. coal	8.00 6.75	1.87	Loss 3%. Coal roughly estimated.
12	Pressed face brick (clay and shale).	Round down-draft	389	1850	w.s. 168 o. 80 s. 88	336	·03 cords wood 216 lbs. coal	9.00 8.30	1.84	Loss 2·6%. Temperature estimated.
13	Wire-cut face brick (clay and shale).	Gas-fired continuous.	200 per chamber	1900	w.s. 30 o. 30 s. 60	120	345 lbs. coal	9.00	2.26	Loss about 1%.
14	Wire-cut face brick (clay and shale).	Rectangular down-draft.	444	1950	w.s. 24 o. 60 s. 60	144	331 lbs. coal	7.07	1.90	Loss about 5%.
15	Pressed face brick (clay and shale).	Up-draft with permanent walls and arches.	420	1875	w.s. 120 o. 120 s. 96	336	·057 cords wood 312 lbs. coal	7.50 6.85	2.30	Loss 2%.
16	Building tile, drain tile (clay).	Round down-draft	100	1800	w.s. 24 o. 38 s. 6	68	361 lbs. coal	6.75	2.42	Loss 4%.

NOTE.—Plants using two types of kilns are given two numbers, thus making sixteen plants shown in the tables when only fourteen were visited.

*w.s. water-smoking. o. oxidation. s. soaking.

As only two plants used Orton pyrometric cones regularly, and the majority rely upon pyrometer readings, it was decided to compare the amount of heat used by the maximum temperature of burning rather than as indicated by the cones brought down, although the cone method would afford better means of comparison. There is a surprisingly large difference in dimensions and weight of brick as well as tile, and no comparison could be obtained if the costs per thousand were given, therefore all figures in the tables are given as cost per ton of burned ware. Any manufacturer who knows his cost per thousand can readily calculate it per ton for purposes of comparison.

The total cost of burning is made up of the following items which are shown separately in Table II:

1. Cost of labour per ton of ware.
   (*a*) Cost of setting;
   (*b*) Cost of firing;
   (*c*) Cost of unloading;
2. Cost at kilns of fuel per ton of ware.

Corrections in the figures furnished have been made in cases where the cost of any one item covers more or less than is commonly included. The labour in firing includes ash removal and general cleanup work at the kilns. An effort was made to include the cost of repairs, but this was finally omitted as the majority of plants were unable to give even a rough estimate of this item for a season. Figures of overhead expenses such as taxes, depreciation, supervision, etc., have been left out as they are more or less complicated, and most manufacturers feel that these contain items which they would not care to give out.

TABLE II

Data on Burning Costs for Brick and Tile

Plant No.	Cost of Labour			Cost of fuel	Total cost of burning
	Setting	Firing	Unloading		
1	$0.35	$0.21	$0.12	$1.44	$2.12
2	0.32	0.21	0.17	1.06	1.76
3	0.17	0.21	0.16	1.90	2.44
4	0.26	0.27	0.24	1.33	2.10
5	0.42	0.07	0.37	0.83	1.69
6	0.35	0.27	0.26	1.16	2.04
7	0.23	0.15	0.22	0.40	1.00
8	0.13	0.23	0.14	0.54	1.04
9	0.13	0.30	0.14	0.50	1.07
10	0.44	0.22	0.27	1.28	2.21
11	0.15	0.16	0.26	1.30	1.87
12	0.14	0.38	0.17	1.15	1.84
13	0.28	0.05	0.38	1.55	2.26
14	0.28	0.19	0.28	1.15	1.90
15	0.23	0.21	0.36	1.50	2.30
16	0.26	0.40	0.54	1.22	2.42

As would be expected the greatest differences in cost are shown in the cost of fuel per ton of ware burned. There are several reasons for these differences. The cost per ton of fuel has a direct bearing on this. Plants which are located at the greatest distances from the source of supply have an added freight rate that may be quite large. Several of the plants visited are situated far from railroads, and have to haul their coal from the freight yards to their plants. The large plants may get the same fuel at a lower price than the small, since they can buy in greater quantities. The average plant which is forced to use wood in water-smoking to prevent the formation of scum is at a disadvantage, because wood is usually more expensive and harder to obtain than coal. Some clays require a higher temperature than others to produce a saleable product, and some manufacturers are forced to burn a kiln longer than the average because of certain physical characteristics of their raw materials.

The type of kiln has a very great influence on the amount of fuel used. Periodic kilns have a higher fuel consumption than continuous kilns. The radiation losses are higher in the periodic type, because they are not insulated as well as the continuous and are, in most cases, exposed to the weather. A strong wind blowing in the fire boxes of a kiln causes a loss of fuel and much trouble to the firemen. The greatest saving in fuel of the continuous kilns is due to the use that is made of waste heat and combustion gases, although a number of periodic kilns are arranged to utilize the waste heat in drying and, in a few cases, the combustion gases for preheating. The top-fired continuous kilns show the lowest fuel consumption of any type, but they can be used only for common brick or tile. Up-draft periodic kilns do not use an excessive amount of fuel, but the percentage of underburned and overburned ware is high. The fuel consumption of the round down-draft kilns varies only little from that of the rectangular, but the round kilns are more easily adapted for the utilization of waste heat.

The most surprising differences in burning costs are those of labour. The cost of labour in firing is fairly uniform when the type and capacity of the kilns are taken into consideration. The cost of setting and unloading varies widely, and sometimes, seemingly without reason. For example, the cost of setting common brick in an up-draft kiln should not be twice as high as in a continuous kiln. There does not appear to be any explanation for the wide differences in the setting cost at some of the plants visited. The variation in unloading costs can be accounted for by the different degree of sorting which is done in the various plants.

The losses in burning as reported by the manufacturers show less variation, and are lower than had been expected. The only case of excessive kiln loss was at plant No. 3 where it averaged 10 per cent.

It would be well for manufacturers to exercise every care in buying coal. Many buy on the word of a salesman if a coal looks good and has a reasonable price and if it works well in burning. No more thought is given to it although another coal might give better results, and even be cheaper in the long run, though the cost per ton was higher. In experimenting with a new coal it is not always given a fair trial because no allowance is made for the variations in ash, sulphur, B.T.U. value, as well as in volatile matter and fixed carbon, and consequently the coal is not manipulated so as to obtain the best results. Table III shows partial analyses and costs, both per ton and per 100,000 B.T.U. of several coals which were collected at the various plants visited.

TABLE III

Data on Coal used in Burning Brick and Tile

Sample	Class of coal	Sulphur per cent.	Ash per cent.	B.T.U. per lb.	Cost of coal per ton	Cost per 100,000 B.T.U.
A	Lump gas coal	0·9	4·3	14,100	$9.00	$0·032
B	" "	3·3	7·5	13,330	9.25	0·035
C	Run-of-mine	4·5	8·8	13,120	5.79	0·022
D	Lump gas coal	0·7	3·4	13,670	10.75	0·039
E	Slack	1·0	8·5	13,450	6.27	0·023
F	Run-of-mine	2·2	8·1	13,330	6.75	0·025
G	" "	1·2	5·8	13,870	8.30	0·030
H	" "	1·2	5·6	13,970	7.07	0·025
I	" "	1·0	6·4	14,010	6.75	0·024
J	Lump gas coal	2·0	9·7	13,410	9.00	0·033
K	Slack	2·8	16·7	12,100	6.58	0·027

There is no doubt that every plant can increase its burning efficiency in one way or another. The use of recording pyrometers has helped many manufacturers, and when properly used they have effected considerable saving. More use should be made of draft gauges, and it might be worth while in many cases to take flue gas analyses at regular intervals, or at least to use a carbon dioxide recorder. Heat curves should be given careful study, the time of burning cut to a minimum, and the heat curves duplicated as closely as possible from one kiln to another. The end of the water-smoking and oxidation periods should be determined by draw trials or some other method so that fuel and time are not wasted by holding kilns at a certain temperature when an advance could be made.

Manufacturers who have their firemen on a contract or bonus basis, report both saving in fuel and an improvement in product. Producing ware of better quality at the same cost or even a little higher cost may serve as a way to increase burning efficiency. Manufacturers who produce ware of superior quality, and who are able to demand a higher price for their product, are justified in having higher burning costs per ton of ware.

There are many ways in which fuel consumption might be lowered, or the efficiency of burning raised, but this is a problem that each manufacturer must work out for himself. Every plant has its own difficulties which are different from those of any other, and what is helpful at one plant might be harmful elsewhere.

Tests on Clays

Samples of the various clays and shales used were collected at each plant, and have been tested according to the standards adopted by the American Ceramic Society. The numbers given these samples bear absolutely no relation to the plant numbers in Tables I and II.

Following is a general description of each sample and the locality from which it was taken.

TABLE IV

Samples Collected

No.	Locality and Description
1	Toronto Brick Co., John Price plant. Dark grey clay, quite plastic, works well, highly calcareous. Tempered with 22½ per cent water.
2	Top shale from Cooksville Shale Brick Co. Dark grey, slightly calcareous, fairly plastic. Tempered with 18 per cent water.
3	Shale from St. Lawrence Brick Co. Dark grey, slightly calcareous, not very plastic. Tempered with 16 per cent water.
4	Clay from St. Lawrence Brick Co. Dark grey, non-calcareous, quite plastic, works well. Tempered with 27 per cent water.
5	Clay from Toronto Brick Co., John Price plant. Soft-mud brick mixture. Dark grey, highly calcareous, quite plastic, works well. Tempered with 20 per cent water.
6	Hard bottom shale from Interprovincial Brick Co. at Milton. Light grey, highly calcareous, somewhat short. Tempered with 18 per cent water.
7	Clay from Cooksville Shale Brick Co. Dark grey, slightly calcareous, quite plastic, has good working qualities. Tempered with 27 per cent water.
8	Lower shale from Cooksville Shale Brick Co. Dark grey, fairly plastic, works well. Tempered with 19 per cent water.
9	Clay from Dennison Interlocking Tile Co. at Tilbury. Dark grey, non-calcareous, quite plastic, works well. Tempered with 34 per cent water.
10	Over clay from Citadel Brick Co. Dark grey, highly calcareous, fairly plastic, works well. Tempered with 24 per cent water.
11	Clay from Paxton and Bray. Grey, highly calcareous, quite plastic, works well. Tempered with 32 per cent water.
12	Soft-mud clay from Price and Smith. Dark grey in colour, highly calcareous, quite plastic, works well. Tempered with 21 per cent water.
13	Over clay from Hamilton Pressed Brick Co. Dark grey, highly calcareous, quite plastic, works well. Tempered with 30 per cent water.
14	Buff shale from Brampton Pressed Brick Co. Light grey, highly calcareous, fairly plastic, works fairly well. Tempered with 18 per cent water.
15	Rock shale from Cooksville Shale Brick Co. Light grey, highly calcareous, quite short. Tempered with 18 per cent water.
16	Shale from Citadel Brick Co. Dark grey, highly calcareous. Rather short. Tempered with 16 per cent water.
17	White (buff) shale from Toronto Brick Co., Milton plant. Light grey, highly calcareous. Tempered with 17 per cent water.
18	White clay from Ollman Bros. Buff in colour, highly calcareous, quite plastic, works well. Tempered with 26 per cent water.
19	Rock sample from Cooksville Shale Brick Co. Dark grey, highly calcareous, very short. Tempered with 21 per cent water.
20	Buff shale near Cheltenham plant of Interprovincial Brick Co. Reddish grey, highly calcareous, quite plastic, works very well. Tempered with 23 per cent water.
21	Weathered shale from Interprovincial pit, Cheltenham. Dark grey, slightly calcareous, fairly plastic, works well. Tempered with 20 per cent water.
22	Rock sewer shale from Toronto Brick Co., Milton plant. Dark red, highly calcareous, fairly plastic, good working qualities. Tempered with 15 per cent water.
23	Dark red shale from Toronto Brick Co., Milton plant. Dark red, slightly calcareous, fairly plastic, works well. Tempered with 16 per cent water.
24	Hard shale from Halton Brick Co. Light grey, highly calcareous, rather short. Tempered with 18 per cent water.
25	Red shale from Halton Brick Co. Dark red, highly calcareous, fairly plastic, works well. Tempered with 17 per cent water.

TABLE IV—*Concluded*

Samples Collected

No.	Locality and Description
26	Red clay from Ollman Bros. Dark brown, non-calcareous, quite plastic, works well. Tempered with 30 per cent water.
27	Clay from Ontario Dennison Tile Co., Fletcher plant. Buff, non-calcareous, very plastic. Works well. Tempered with 30 per cent water.
28	Top clay from Cooksville Shale Brick Co. Light grey, slightly calcareous, very plastic, works well. Tempered with 30 per cent water.
29	Soft sewer shale from Toronto Brick Co., Milton plant. Light red, highly calcareous, rather short, works well. Tempered with 16 per cent water.
30	Sewer shale from Interprovincial Brick Co., Milton plant. Red in colour, highly calcareous, fairly plastic, works well. Tempered with 18 per cent water.
31	Ground shale from Brampton Pressed Brick Co. Dark red, highly calcareous, fairly plastic, works well. Tempered with 15 per cent water.
32	Buff shale from Interprovincial Brick Co., Milton plant. Light red, highly calcareous, fairly plastic, works well. Tempered with 16 per cent water.
33	Red shale from Interprovincial Brick Co., Milton plant. Dark red, highly calcareous, fairly plastic, works well. Tempered with 15 per cent water.
34	Clay, between surface clay and shale, from Cooksville Shale Brick Co. Light buff, slightly calcareous, quite plastic, works well. Tempered with 22 per cent water.
35	Pink buff clay from Toronto Brick Co., Milton plant. Light red, highly calcareous, fairly plastic, works well. Tempered with 16 per cent water.
36	Shale from pit of Booth Brick and Lumber Co. Light grey, slightly calcareous, fairly plastic, works well. Tempered with 18 per cent water.
37	Ground shale from Booth Brick and Lumber Co. Dark grey, slightly calcareous, fairly plastic, works well. Tempered with 17 per cent water.
38	Shale from Hamilton Pressed Brick Co. Dark red, slightly calcareous, fairly plastic, works well. Tempered with 17 per cent water.
39	Light red shale from Toronto Brick Co., Milton plant. Light red, slightly calcareous, fairly plastic and works well. Tempered with 22 per cent water.
40	Buff shale from ravine near Cheltenham. Light grey, highly calcareous, fairly plastic, works well. Tempered with 19 per cent water.
41	Hard shale from Cooksville Shale Brick Co. Light grey, slightly calcareous, fairly plastic, works well. Tempered with 19 per cent water.
42	Red shale from Brampton Pressed Brick Co. Dark red, highly calcareous, fairly plastic, works well. Tempered with 17 per cent water.
43	Top red shale near Cheltenham. Dark red, highly calcareous, quite plastic, works well. Tempered with 24 per cent water.

Seven briquettes of each sample were burned, one each at cone 015, 012½, 010, 08, 06, 04, 02. As each cone was brought down a set of trials was drawn from the kiln. The burning time was a little under 30 hours, and after drawing the first set of trials, about two hours was required to bring down each successive cone at which briquettes were drawn.

The best burning temperature has been judged by the shrinkage and absorption curves, the colour, and general condition of the briquettes.

TABLE V

Properties of Clays and Shales used in manufacture of Brick and Tile

	Plastic and Dry Properties							Burned Properties					
									At best burning temperature				
No.	Water of plasticity per cent.	Pore water per cent.	Shrinkage water per cent.	Plasticity	Dry transverse strength lbs. per sq. in.	Dry volume shrinkage per cent.	Dry linear shrinkage per cent.	Best burning temperature	Burned linear shrinkage per cent.	Burned volume shrinkage p.c.	Burned absorption per cent.	Colour	Softening point
1	22·5	11·9	10·6	Quite plastic..	603	21·4	7·7	Cone 06.......	4·6	13·3	14·9	Good red.........	Cone 3
2	18·0	11·5	6·5	Fairly plastic.	95	13·7	4·8	" 04......	1·3	3·3	9·4	Good red.........	" 3½
3	16·0	10·8	5·2	Short.........	76	11·0	3·8	" 06......	0·5	1·4	10·3	Good red.........	" 3½
4	27·0	12·5	14·5	Quite plastic..	363	28·0	10·3	" 08......	1·8	5·2	13·9	Good red.........	" 2
5	20·0	11·6	8·4	" " ..	467	16·8	6·0	" 04......	1·4	4·2	14·6	Good red.........	" 3
6	18·0	13·7	4·3	Short.........	63	8·7	3·0	Higher than 02	....	....	....	....	" 7½
7	27·0	12·6	14·4	Quite plastic..	357	28·4	10·6	" 06......	5·0	14·1	6·9	Good red	" 3½
8	19·0	12·1	6·9	Fairly plastic	113	14·6	5·1	" 08......	1·4	4·0	11·1	Good red.........	" 2
9	34·0	13·5	20·5	Very plastic..	738	38·2	14·3	" 06......	2·5	7·4	14·4	Good red.........	" 4
10	24·0	14·2	9·8	Fairly plastic	176	18·4	6·6	" 08......	0·8	2·3	19·5	Good red.........	" 3½
11	32·0	14·9	17·1	Quite plastic.	389	32·5	12·3	" 08......	1·5	4·7	19·4	Fair red..........	" 3
12	21·0	12·8	8·2	" "	476	16·4	5·8	" 06......	0·9	2·6	16·1	Good red.........	" 3
13	30·0	16·2	13·8	" "	409	27·5	10·2	" 08......	3·5	10·4	16·9	Light red.........	" 3
14	18·0	12·5	5·5	Fairly plastic.	97	11·4	4·0	" 04......	0·3	1·0	17·5	Fair buff..........	" 4
15	18·0	13·5	4·5	Very short....	51	9·1	3·2	" 06......	−0·4	−1·1	17·7	Reddish buff.....	" 4
16	16·0	10·0	6·0	Fairly plastic.	171	9·6	3·3	" 06......	−0·4	−1·1	16·9	Good buff........	" 4
17	17·0	11·7	5·3	Rather short.	102	11·3	4·0	" 04......	−1·2	−3·6	20·0	Buff...............	" 5½
18	26·0	16·8	9·2	Quite plastic..	200	17·6	6·2	" 06......	3·2	9·1	20·4	Poor buff..........	" 3
19	21·0	13·5	7·5	Very short..	156	14·8	5·2	" 02......	3·8	11·0	12·5	Light buff.......	" 6
20	23·0	12·0	11·0	Quite plastic..	222	22·2	8·0	" 06......	−0·4	−1·2	18·6	Fair reddish buff.	" 4
21	20·0	11·8	8·2	Fairly plastic.	94	16·9	6·0	" 08......	0·5	1·5	13·6	Fair red..........	" 2
22	15·0	9·4	5·6	" "	95	12·3	4·4	" 08......	0·6	1·7	13·3	Good red.........	" 2½
23	16·0	8·8	7·2	" "	88	15·7	5·5	" 06......	1·7	5·2	7·9	Dark red..........	" 2
24	18·0	13·6	4·4	Rather short.	50	8·8	3·0	Higher than 02	....	....	....	....	" 6½
25	17·0	10·7	6·3	Fairly plastic.	85	17·9	6·4	Cone 04......	0·0	0·0	13·7	Fair red..........	" 3
26	30·0	14·1	15·9	Very plastic..	368	30·3	11·4	" 08......	1·2	3·7	15·4	Light red.........	" 2
27	30·0	13·1	16·9	" "	532	32·6	12·3	" 08......	0·9	2·5	15·1	Good red.........	" 3
28	30·0	13·1	16·9	" "	432	33·0	12·5	" 08......	2·0	5·9	12·9	"	" 2
29	16·0	10·6	5·4	Rather short.	55	11·8	3·9	" 04......	−0·4	−1·1	17·4	Reddish buff.....	" 4
30	18·0	10·9	7·1	Fairly plastic	75	15·2	5·4	" 02......	1·2	3·8	12·8	"	" 4
31	15·0	8·9	6·1	" "	95	13·4	4·7	" 06......	1·4	4·2	11·8	Fair red..........	" 2½
32	16·0	10·1	5·9	" "	92	12·9	4·5	" 04......	−0·6	−1·9	12·8	Buff...............	" 3½
33	15·0	9·4	5·6	" "	89	12·3	4·3	" 06......	0·9	2·5	11·7	Reddish buff.....	" 3

34	22·0	13·1	8·9	Quite plastic..	196	17·9	6·4	" 04......	−0·5	−1·2	15·8	Buff.............	"	3½
35	16·0	10·8	5·2	Fairly plastic.	85	11·5	4·0	" 04......	0·9	2·6	15·8	Buff.............	"	4
36	18·0	10·7	7·3	" "	100	15·6	5·5	" 08......	0·3	1·0	10·6	Pinkish buff......	"	2
37	17·0	10·4	6·6	" "	122	14·1	5·0	" 08......	1·8	5·4	10·8	Good red.........	"	2
38	17·0	10·7	6·3	" "	94	13·8	4·8	" 08......	0·0	0·0	10·9	Fair red..........	"	2½
39	22·0	13·2	8·8	Quite plastic..	133	18·0	6·4	" 06......	1·2	3·6	14·4	Reddish buff.....	"	3
40	19·0	11·5	7·5	" "	145	15·2	5·4	" 04......	−0·8	−2·2	20·4	Buff	"	5
41	19·0	10·3	8·7	Fairly plastic.	107	18·2	6·5	" 06......	3·2	9·1	7·0	Good red.........	"	2
42	17·0	10·3	6·7	" "	100	14·2	5·0	" 08......	1·2	3·8	12·4	Light red.........	"	2
43	24·0	13·0	11·0	Quite plastic..	235	22·0	8·0	" 04......	1·5	4·7	15·5	Dark brownish red.	"	4

IV

INVESTIGATIONS OF ROAD MATERIALS IN NEW BRUNSWICK AND NOVA SCOTIA

R. H. Picher

The greatest part of the field work of 1924 consisted in examining and sampling gravel deposits in New Brunswick to determine the suitability of the gravels for road purposes. Gravel from more than half of the deposits had already been used for road work, so that its behaviour in actual service could be carefully noted. A large number of quarries and bedrock exposures were also visited with the view of determining their value as a future source of supply for material in the building of more permanent types of roads and pavements. All outcrops showing good stone were examined in detail and sampled.

In Nova Scotia, about two weeks were spent in making a thorough investigation of all materials encountered in areas devoid of durable road stone with a view to pointing out such as could possibly be used to render the main roads passable until such time as the increase of traffic warrants the bringing of better material from outside sources.

At the completion of the field season in New Brunswick and Nova Scotia, while passing through the province of Quebec on the return journey to Ottawa, several samples of Trenton limestone were taken from quarries situated at different points along the north shore of the St. Lawrence river. On account of the frequency of its occurrence, this stone is extensively used for various purposes, and it was deemed advisable to ascertain its properties as road metal and compare the results of the tests with those already obtained on stone of the same formation exposed at several places in western Quebec and eastern Ontario, more particularly in the Montreal and Ottawa districts.

The investigational work in New Brunswick was confined, with a few exceptions, to areas along or within hauling distance of the provincial highways. Of these the most important are: the Campbellton-Bathurst-Newcastle highway; the Chatham-Moncton highway; the Moncton-Aulac highway; the Moncton-St. John highway; the St. John-Fredericton highway; the Fredericton-Woodstock-Edmundston highway; the Fredericton-St. Stephen highway; the St. Stephen-St. John highway, and the Fredericton-Newcastle highway. All material occurring along the above-mentioned highways was noted, and that which appeared suitable for road-surfacing purposes was carefully examined and ninety samples were collected for testing.

As already mentioned gravel and bedrock were the two main types of materials considered in the investigation. Both are very common throughout the province. Although the bedrock exposures are much more uniformly distributed than gravel deposits, the difference in uniformity of distribution becomes less apparent when suitable road stone is taken into consideration. This is due to the fact that within large areas, all bedrock exposures show a very friable stone, unfit for use in road work, whereas areas in which poor gravel is found are much smaller in extent. Since rock outcrops are most common in the highlands, and gravel deposits in the lowlands, gravel appears to be of more frequent occurrence than bedrock along the main highways, which commonly follow river or coast lines.

NEW BRUNSWICK

Apart from a few miles of bituminous macadam, all the improved main highways are built of gravel. Through an efficient patrol system in New Brunswick, the road surfaces are maintained in good condition at all times by patching and dragging. Gravel roads have given very good service for several years and will continue to do so for some time to come, although it is becoming apparent that with the present rate of increase in automobile traffic, some of the highways will have to be surfaced with a more durable type of gravel than at present used. Most of the gravels now in use are fairly well graded, but many of them carry too much sand and too many soft or friable particles. The use of coarser and harder gravels with, if found necessary, the addition of a binder, will reduce the wear on the road. A coarser gravel does not necessarily mean a gravel carrying larger particles, but one with a larger average size of particle, and this could easily be obtained in the case of many gravels now in use by simply screening out part of the sand. To obtain the best results with such gravels it may be found advisable to improve the method of construction and build the road in at least two courses.

GRAVEL

Gravels are generally common along the main highways of the province. They are quite numerous on the hilly tract along the bay of Fundy, between St. John and the international border, and along stretches of road adjacent to the larger streams, such as the Miramichi, Kennebecasis, and St. John rivers. They are very sparsely distributed throughout the level land in the eastern half of the province, which is underlain by horizontal strata of Millstone Grit sandstone. Most of the deposits are of small extent and are not grouped along a definite direction, but rather occur as isolated units. This does not apply to the deposits that either lie along river shores or form bluffs facing river flats, and which in many cases can be traced for several miles along the streams. With regard to size of particles, the gravels generally carry a high proportion of sand, from one-third to two-thirds, and very little silt and clay. Boulders are found in only a few deposits and are generally confined to the upper 3 or 4 feet.

Tables I and II give the results of tests made upon seventy-five gravel samples collected mostly along main highways. The samples with double numbers, one of which is within brackets, were included in the report for 1923, and have been inserted in the present report on account of additional tests having been made upon them during the current year. Pebble includes all material over one-quarter inch in size, and sand everything under one-quarter inch. In the very few cases where the boulders, or material over 3 inches in size, are in fairly high amount, that is to say over 10 per cent of the total deposit, mention of it is made in the remarks. The percentage of clay and silt is taken from the percentage passing a 200-

mesh sieve. It is somewhat lower than when determined directly by washing the sample, but the difference is very small, since most of the gravels are very clean, and perfectly dry when tested. Moreover, the percentage of clay and silt is very low in nearly all samples tested, so that the method followed in determining it can be considered accurate enough for the purpose of the present investigation. The classification of the gravel pebbles into durable, intermediate and soft types is based on their nature and soundness. Broadly speaking, "durable" pebbles include hard, finely crystalline igneous and metamorphic rocks; "intermediate," relatively soft and coarsely crystalline igneous rocks, schistose metamorphic rocks, limestone, glassy or fine-grained, compact sandstone, and slate, when not splitting too readily; "soft," sandstone, shale, shaly limestone, weathered rocks of all kinds. The most common rocks encountered in each sample are named in the remarks.

There is no uniform method yet accepted for determining the per cent of wear of gravel. The method followed in this case is the one adopted by the American Association of State Highway Officials and approved by the U.S. Secretary of Agriculture for use in connexion with Federal-aid road construction. Since it has not been published in previous reports, a description of it follows:[1]

Abrasion Test for Gravel.—The aggregate shall first be screened through screens having circular openings 2 inches, 1½ inches, 1 inch, three-quarters inch and one-half inch in diameter. The materials of these sizes shall be washed and dried. The following weights of the dried stone shall then be taken: 1,250 grams of the size passing the 2-inch and retained on the 1½-inch screen, 1,250 grams of the size passing the 1½-inch and retained on the 1-inch screen, 1,250 grams passing the 1-inch and retained on the three-quarters inch screen, 1,250 grams passing the three-quarters inch and retained on the one-half inch screen. This material shall be placed in the cast-iron cylinder of the Deval machine as specified for the standard abrasion test on stone. Six cast-iron spheres 1·875 inches in diameter and weighing approximately 0·95 pound (0·45 kilogram) each shall be placed in the cylinder as an abrasive charge. These spheres are the same as those used in the standard rattler test for paving brick.

"The duration of the test and the rate of rotation shall be the same as specified for the standard test for stone, namely, 10,000 revolutions at a rate of 30 to 33 revolutions per minute. At the completion of the test the material shall be taken out and screened over a one-sixteenth inch mesh sieve. The material retained upon the sieve shall be washed and dried and the percentage loss by abrasion of the material passing the one-sixteenth inch mesh sieve calculated.

"When the material has a specific gravity below 2·20 a total weight of 4,000 grams made up of the four groups of sizes described above, instead of 5,000 grams, shall be used in the abrasion test.

Following is a brief enumeration of the more important gravel deposits found along the several main highways covered by the present investigation.

Campbellton-Bathurst Highway

There are comparatively few bank gravel deposits along this road. The only ones showing good material are found scattered for several miles west of Benjamin river. Deposit No. 13 (Tables I and II) is too sandy, but could be used to advantage if part of the sand were screened out. Beach and river gravels are easily available at many points, except between Campbellton and the Quebec border where the high level of the road and the very steep slopes from the shore make hauling difficult. Most of

[1] From Bulletin No. 1216, United States Department of Agriculture, entitled: "Tentative Standard Methods of Sampling and Testing Highway Materials."

the beach gravels are very hard and do not compact readily on roads, unless applied in thin layers. They have been used for years in road surfacing with very good results.

Bathurst-Newcastle Highway

Large deposits of very good gravel lie along the east bank of Nipisiguit river, southeast of Bathurst (No. 35). Seven miles southeast of Bathurst, stream gravel from the bed of Bass brook, has proved good surfacing material. From this point south to Newcastle, a distance of over 40 miles, the very few gravel deposits encountered are composed entirely of friable sandstone, much too soft for satisfactory road surfacing.

Chatham-Moncton Highway

There are a few small deposits scattered throughout Kent county (Nos. 45, 52), but elsewhere gravel is totally wanting. All these gravels are composed entirely of friable sandstone. All along this highway and the Bathurst-Newcastle highway, there are numerous places where the underlying rock, Millstone Grit sandstone, lies close to the surface. The upper two feet of the rock is generally partly disintegrated into small flat pieces, which are used in road surfacing in the same way as gravel. Sandstone, whether in the form of gravel or loose rock, is the only material available from Moncton to nearly as far as Bathurst, or along a total distance of over 100 miles. The stone, composed of quartz and intensely altered feldspar, crumbles readily on the road, forming a sand-clay surface, which is generally in fairly good condition, whether dry or wet. There are many stretches of road in which there is either an excess of sand or an excess of clay, and of course the weather greatly affects their condition. The surfacing of this road with gravel from outside sources would incur a heavy outlay, and it is doubtful whether the present amount of traffic would justify the expense. It would be well to make a thorough study of the road subsoil and local sandstone, so as to utilize both in the building of a good sand-clay road.

Moncton-Aulac Highway

Partly disintegrated quartz conglomerate, outcropping at several places between Moncton and Dorchester and near Aulac (Nos. 56, 59, 64), has been extensively used for surfacing the main road, and also shipped to outside points for the same purpose. It has been found to be much more satisfactory than natural gravel. The latter is very scarce and carries a high proportion of sand. The conglomerate is more expensive to obtain than ordinary gravel, on account of occasionally having to be drilled and blasted but it is the only durable surfacing material available locally. Although containing many hard, smooth, rounded pebbles, the material compacts fairly well, but the road surface never becomes very smooth.

Moncton-St. John Highway

From River Glade to Hampton, gravel deposits are fairly common, most of them being of small size. Between Moncton and River Glade, there are occasional lenses or pockets of fine gravel in large sand deposits, but they are of no value for road surfacing. Between Hampton and St.

John, there are no regular gravels for road-surfacing purposes, although pits have been opened in gravelly and bouldery drift deposits.

The best road gravels are located between Kedron and Sussex (Nos. 73, 77, 78). No. 78 is excavated from the bed of Trout creek and screened to several sizes. It is extensively used in and around Sussex and shipped outside for road purposes. Like all river gravels composed of hard particles, it should be applied on the road in several layers. For best results the addition of a binder is necessary. The conglomerate exposed along the Cornhill road, 1½ miles west of Petitcodiac, is a very good surfacing material and should be more extensively used on the main road. From Sussex to Bloomfield the gravels are very sandy (Nos. 80, 85), and do not seem to be durable enough to stand the fast automobile traffic to which the main road is subjected. There is a very large amount of gravel between Centre Norton and Hampton. Most of it is bouldery and very irregular in size but fairly hard. By crushing the boulders and screening both gravel and crushed boulders in two sizes, a good, durable, two-course gravel road could be built with the material. On account of the scarcity of regular gravel between Hampton and St. John, pits have been opened at a few places in drift material (Nos. 89, 90). The drift carries pockets of suitably sized stone, but on the whole it is very irregularly sorted and very bouldery. The most satisfactory way of utilizing the stone would be to crush the boulders, which are largely gneissic granite, and mix the crushed product with the fine drift material. Since good crushed stone could be obtained from St. John at a lower cost than if the boulders were crushed, it would probably be preferable to get the stone from St. John and build either a bituminous macadam road or a broken stone road with bituminous surface treatment on the Hampton-Rothesay section, as has already been done on the Rothesay-St. John section.

St. John-Fredericton Highway

Gravels are very common from St. John to Welsford, and very scarce farther north. Along the St. John-Welsford section, the gravels are generally very hard and carry an excess of sand. Nos. 99 and 102 are the only two deposits carrying regular size gravel. Most of the other gravels could be turned into good surfacing material by eliminating part of the sand. North of Welsford, the few deposits lying along the road show very poor material, except No. 113, which has proved satisfactory in service, although carrying an excess of sand. A small amount of conglomerate, 3½ miles south of Geary settlement, has recently been used for patching the main road. The conglomerate lies horizontally, is interbedded with sandstone, and for that reason it may prove expensive to obtain in large quantity, but it is certainly a much better material than the local gravel.

Fredericton-Edmundston Highway

This highway for nearly its entire length, follows the shore of the St. John river. Gravels are fairly regularly distributed between Pokiok and Grand Falls, but are nowhere very common. From Grand Falls to Edmundston and from Pokiok to the St. Stephen road, gravels are relatively scarce, and from the St. Stephen road to Fredericton, they are totally wanting. Most of the gravels between the St. Stephen road and Aroostook are fairly durable. Nos. 118 and 131 are particularly good. All the deposits lying between Meductic and Hartland show very irregularly graded material. On the road these gravels wear well, except around Hartland where they are somewhat too soft. Between Aroostook and Edmundston, the gravels are generally less durable than the ones found farther south. On account of the lateness of the season, no detailed study was undertaken to determine the suitability of these gravels as road-surfacing material.

There are also many gravelly flats along the shore and around the islands of the St. John river. Very little of these gravels has been used on roads so far, except in the section between Fredericton and the St. Stephen road, which has been entirely surfaced with river gravel, and is in very good condition.

Fredericton-St. Stephen Highway

There are a few gravel deposits between Thomaston and Brockway, and a few miles north of St. Stephen; elsewhere the gravel is very scarce. The gravels south of Thomaston are very irregular in size, from very bouldery to nearly all sand. Towards Brockway they gradually become more regular in size. The gravels north of St. Stephen are very sandy. Nos. 151, 157, 158 (north of Lawrence; not sampled), and 163 are among the more suitable deposits. No. 149 is very poor, being largely composed of soft, schistose rocks which readily crumble under traffic to a clayey powder. On the whole, suitable surfacing material is very scarce along this highway, so that every available material which will temporarily improve the road surface is being utilized. On some sections, the use of durable gravel obtained from outside sources is not feasible, due to the cost of hauling the material.

St. Stephen-St. John Highway

Gravel deposits are numerous and very regularly distributed along this highway, except for several miles around St. Andrews and St. John, where they are decidedly scarce. Nearly all of them are of small extent and show rather fine gravel, carrying a high percentage of sand, and very little silt and clay. Since all the gravels are composed almost exclusively of hard particles, they could be made very good surfacing material by proper re-grading, where necessary, and eliminating part of the sand. Some of them are so hard that it is doubtful whether they would bind at all on the road, and in such cases the addition of a little clay would greatly improve conditions. Drift deposits, such as No. 189, are not uniform enough to be considered satisfactory road material, but can well supply the fine binding material which is totally lacking in many of the regular gravels.

Fredericton-Newcastle Highway

The road follows closely the shore of the Nashwaak river for a distance of about 25 miles, then passes over to the Miramichi river, which it follows somewhat closely down to Newcastle. Since all the gravels in the district lie very close to either the Nashwaak or the Miramichi river, they will be found of common occurrence along those sections of the highway close to the river shores, and almost totally wanting elsewhere. On the whole they are nowhere very common. Between Blissfield and Newcastle they carry a high proportion of sand, but they are all fairly regularly graded. Nearly all gravels are hard enough for durable road surfacing. No. 224 (1½ miles northeast of Marysville; not tested) is the only gravel which is undoubtedly too soft. Some of the gravels between Blissfield and Newcastle would be greatly improved if part of their sand were eliminated before using.

In the above enumeration, the suitability of gravels for road-surfacing purposes was judged from laboratory and service tests under present traffic conditions, but there is no doubt that at the present rate of increase in automobile traffic on all the main highways of the province, many gravels which have up to the present given good service on roads will soon have to be discarded as wearing too fast.

EXPLANATION OF TABLE III

A mortar test was run on fifteen samples (Table III). In collecting samples an effort was made to have a fair representation of large deposits, or group of small deposits presenting certain characteristics which might affect the suitability of the material for concrete purposes. The standard test referred to in the table is made on a mortar composed of 1 part of cement and 3 parts of standard Ottawa sand. Mortars giving results of ess than 70 per cent of the value of the standard test should be rejected.

TABLE I

Results of Physical Tests Upon Gravel Samples

Sample No.	Location	Granulometric Analysis: Proportion of pebble to sand: Per cent pebble	Per cent sand	Pebble: Per cent retained on screens: 2½"	2"	1½"	1"	¾"	½"	¼"	Sand: Per cent retained on sieves: 8	14	28	48	100	200	Per cent passing 200 mesh	Remarks
11	2½ m. S. of Dalhousie.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Beach gravel, free of boulders and very regular in size. Wears well on road.
13	1m.E.of River Charlo	35	65	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Very irregularly graded and carries much sand. Somewhat too fine and too soft for durable road surfacing.
35	1⅓ m. SE. of Bathurst.	77	23	10	4	12	33	12	15	14	20	8	12	39	15	3	3	Grading about right. Gravel a little too hard and lacks binder, but quite suitable for roads and wears very well.
45	2½ m. NW. of St.Louis	61	39	13	5	22	13	10	15	22	13	4	7	55	14	3	4	Regularly graded, but much too soft for durable results. On the road the gravel crumbles readily and forms a good surface which remains smooth at all times under light traffic, if dragged often.
52	¾ m. SE. of St. Gregoire.	49	51	0	5	5	19	20	27	24	11	5	11	51	17	3	2	Same as No. 45.
56 (46)	2 m. NW. of Memramcook West (Highway Division's pit).	65	35	0	0	7	21	14	25	33	35	22	17	9	5	4	8	Rusty conglomerate, fairly well graded. Has given good service on roads for several years.
57	2 m. NW. of St.Joseph	27	73	0	0	0	5	6	16	73	41	27	17	7	3	2	3	Looks like weathered conglomerate. Grading too fine and proportion of ¼-inch and 8 mesh too high. Unsuitable for use on main road. Used with good results on local earth roads.
59	S. of College Bridge..	68	32	0	0	5	11	14	28	42	45	16	11	10	9	4	5	Same as No. 56, but does not bind so readily on roads.
64	E. of Aulac (Highway Division's pit).	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Conglomerate about the same as No. 56, but much harder to loosen. This is the only suitable road-surfacing material found for several miles.

TABLE I—Continued

Results of Physical Tests Upon Gravel Samples—Continued

Sample No.	Location	Granulometric Analysis																Remarks
		Proportion of pebble to sand		Pebble							Sand							
				Per cent retained on screens							Per cent retained on sieves						Per cent passing 200 mesh	
		Per cent pebble	Per cent sand	2½"	2"	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200		
67	2 m. NE. of River Glade (Power's pit).	65	35	3	4	24	24	10	14	21	29	18	23	21	6	2	1	Rather coarse, regularly graded. Very good.
72	1½ m.SW. of Portage.	34	66	0	0	5	15	10	24	46	24	20	23	20	9	2	2	Fairly regularly graded, sandy gravel. Makes a smooth road surface, but not hard, on account of holding too much sand. Sample coarser than average of deposit.
73	1¾ m. NE. of Kedron.	68	32	5	6	18	20	13	16	22	32	20	19	19	7	2	1	Sample from upper part of bank, where gravel is coarser than pit average. Regular size gravel quite suitable for roads.
77	S. of Plumweseep.....	74	26	9	15	11	22	13	17	23	41	21	16	12	4	2	4	Sample coarser than pit average. Very irregularly graded. Several other pits show fairly regular size gravel, used with good results.
78	Sussex..............	.....	.....	...	...	...	...	...	...	...	..	..	..	..	...	...	.....	Large flats of stream gravel varying much in coarseness from place to place. Extensively used for road surfacing in various parts of the province. Deficient in binder, but otherwise quite suitable.
80	1½ m. W. of Sussex....	44	56	0	4	5	17	16	21	37	21	17	19	19	14	7	3	Irregularly graded, sandy gravel. Somewhat too soft for surfacing main road. Gravel No. 78 is preferably used for that purpose.
85	Bloomfield..........	35	65	...	...	...	...	...	...	...	..	..	..	..	...	...	.....	Gravel flats along Kennebecasis river. Here the gravel is fine and very sandy. Unsatisfactory on account of carrying too much sand.
89	1¾ m. NE. of Rothesay.	54	46	8	0	13	17	16	20	26	26	16	15	13	10	7	13	Drift material holding about 15 per cent of boulders. Pebble content varies much from place to place. Unsuitable because of holding too much fine material.

90	1¼ m. NE. of Rothesay.	50	50	....	....	....	....	....	....	....	..	..	..	..	....	....	......	Same as No. 89, but holds 10 per cent of boulders.
94	3 m. SE. of St. John..	70	30	0	3	7	17	17	26	30	46	25	12	5	3	4	5	Very regularly graded, but sand too coarse. Takes long to compact on road. Deposit along Mispek road, and 3 miles from main road.
98	1¼ m. SE. of Westfield station.	43	57	0	0	9	18	10	19	44	43	30	17	6	2	1	1	Regularly graded, very fine, sandy gravel. Unsatisfactory because of holding too much sand and not binding readily on road. Sample coarser than pit average.
99	Woodmore Point......	64	36	4	6	5	15	11	24	35	41	27	16	8	4	2	2	Regular size gravel, wearing well on road. Although it does not compact readily, is better than other gravels found around here.
102	3 m. SE. of Welsford.	62	38	3	14	9	19	14	18	23	27	26	27	14	3	1	2	Very irregularly graded, loose gravel, interstratified with much sand. Does not compact readily, but durable. Sample coarser than average as seen by several pits.
105	½ m. SE. of Welsford (Thomson's pit).	28	72	0	0	0	6	5	19	70	40	19	13	22	5	1	0	Percentage retained on ¼-inch and 8 mesh too high. Gravel carries too high proportion of sand to give good results on roads.
113	4 m. S. of Oromocto (Highway Division's pit).	43	57	0	1	1	17	15	22	44	29	18	20	25	6	1	1	Regularly graded, sandy gravel; over ⅔ sand. Sample coarser than pit average. Used with good results on road. Rather too fine for durable surfacing.
118	3 m. NE. of Pokiok..	67	33	0	3	14	26	14	18	25	28	15	11	22	19	2	3	Good durable gravel, much used for road surfacing.
121 (57)	1 m. W. of Allandale (Grant's pit).	45	55	0	0	0	3	14	28	55	32	22	14	16	12	3	1	Large sand pit, one bank showing regular size gravel, but carrying a rather high proportion of sand. Gravel has given good service on road surfaces.
123	½ m. W. of Meductic (Highway Division's pit).	77	23	14	10	17	17	10	14	18	45	29	14	4	2	1	5	Pit as a whole shows very irregularly graded, coarse, clayey gravel. Individual layers show gravel very regular in size. Makes a good smooth road surface, fairly durable. Sample coarser than average of pit.
124 (58)	½ m. N. of Lower Woodstock. (Highway Division's pit).	71	29	0	5	4	9	11	32	39	29	18	19	15	6	4	9	Same as No. 123.
126 (59)	1½ m. W. of Woodstock (Highway Division's pit).	69	31	0	0	20	24	16	17	23	37	30	21	7	2	1	2	Same as No. 123.
127	5 m. S. of Hartland (Highway Division's pit).	71	29	4	9	20	18	12	14	23	33	25	17	8	4	3	10	Very irregularly graded, clayey gravel. Too irregular in size and too soft for durable results on roads. Sample coarser than average.

TABLE I—Continued

Results of Physical Tests Upon Gravel Samples

Sample No.	Location	Granulometric Analysis: Proportion of pebble to sand: Per cent pebble	Per cent sand	Pebble: Per cent retained on screens: 2½"	2"	1½"	1"	¾"	½"	¼"	Sand: Per cent retained on sieves: 8	14	28	48	100	200	Per cent passing 200 mesh	Remarks
129 (60)	2 m. N. of Hartland..	84	16	4	13	9	22	12	19	21	41	8	7	9	10	14	11	Same as No. 127.
131	1¼ m. NW. of Riverbank.	67	33	3	2	11	23	17	18	26	30	18	23	17	5	2	5	Good, regular size gravel, extensively used for roads. Wears well.
139 (61)	2 m. S. of Perth (Highway Division's pit).	70	30	0	5	10	27	18	18	22	21	9	21	41	6	1	1	Regularly graded, hard gravel. Proportion of sand rather low. Much used for road surfacing with very good results.
145	2¾ m. S. of Grand Falls.	46	54	0	4	13	16	12	20	35	24	18	20	19	10	4	5	Very regularly graded, rather soft gravel. Unsuitable for main roads on account of wearing too fast.
149 (53)	2 m. SE. of Newmarket (Highway Division's pit).	48	52	0	15	8	11	14	20	32	21	28	30	11	3	2	5	Size varies a great deal from place to place. Very poor surfacing material. Wears fast and forms slippery surface when wet.
150	3 m. SE. of Newmarket.	56	44	0	4	11	17	13	21	34	27	18	15	15	9	6	10	Conglomerate and sandstone, loosened with pick and used on road. Hard to loosen and on road has a tendency to crumble into sand. Pebble per cent includes many lumps of sand. Sample coarser than pit average.
151 (54)	4¼ m. S. of Newmarket (Highway Division's pit).	63	37	0	12	12	29	13	15	19	23	18	21	14	8	8	8	Gravel irregular in size but fairly good. Compacts and wears well on road. This is the best material found between Harvey and the Woodstock River road.
154 (55)	1 m. SE. of Thomaston	54	46	4	19	24	21	8	9	15	20	26	34	16	2	1	1	Very coarse and irregularly graded gravel, carrying about 30 per cent boulders. Size varies widely. Another pit nearby shows mostly sand. Needs to be screened and re-graded, if used for road surfacing.

157	1½ m. N. of Brockway	56	44	4	0	9	19	16	21	31	33	16	14	22	9	3	3	Good gravel, very uniform in size. Quite suitable for road surfacing, although does not compact readily.
163	4¼ m. N. of St. Stephen	36	64	0	7	6	19	13	15	40	19	19	39	19	2	1	1	Very regular in size but carries too much sand. Used on road with good results.
166	3 m. N. of St. Stephen (Hay's pit).	56 41	44 59	6 8	7 5	8 2	14 22	13 10	23 21	29 32	28 15	17 25	20 34	21 18	9 5	2 1	3 2	Sample of fine gravel, from lower part of bank, and of coarse gravel from upper part of bank. Irregularly graded. Pit shows mostly very fine gravel and sand, unsuitable for road surfacing.
168	3 m. NE. of St.Stephen.	61	39	6	7	15	16	12	19	25	22	25	37	9	2	2	3	Fairly regularly graded gravel, used on road with very good results. Sample coarser than average.
169	S. of Oak Bay (Young's pit).	65	35	0	7	11	26	14	18	24	23	20	26	18	6	3	4	About the same as No. 169, but better on account of being more regular in size.
171	3 m. SE. of Oak Bay.	69	31	0	4	9	19	15	22	31	37	22	15	11	8	4	3	Very regularly graded. Very good and durable material, much used for road surfacing.
175	3½ m. W. of Bocabec.	80	20	5	17	9	21	14	13	21	45	21	13	8	5	3	5	Irregularly graded, hard gravel, clayey in places. Proportion of sand rather small. Sample slightly coarser than pit average. Suitable for roads.
181	Bocabec.............	63	37	0	9	9	20	12	18	32	42	25	17	7	3	3	3	Coarse, loose gravel, very irregular in size. Lower part of bank very clayey. Much used for road surfacing. Would probably give very good results if screened and re-graded.
184	5 m.NW.of St. George	45	55	0	3	10	10	13	22	42	37	24	13	11	9	4	2	Fine, hard gravel. Takes long time to compact on road, on account of carrying too much sand, and very little binder.
189	2½ m. NW. of St. George.	68	32	0	2	14	23	15	19	27	33	13	8	6	9	14	17	Drift carrying layers of gravelly sand. Material very irregularly sorted as to size of particles. Unsuitable for roads.
190	2 m. NW. of St.George	70	30	0	5	9	13	20	26	27	18	11	18	25	19	7	2	Regularly graded, very hard gravel. Lacks binder and carries too small proportion of sand. Should prove very good for roads if binder added.
197	1½ m.E. of St. George	72	28	13	5	6	27	13	15	21	31	15	9	7	10	14	14	Fairly regularly graded, very hard gravel. Sample coarser than pit average. Much used on roads with very good results.
200	½ m. E. of Pennfield Centre.	73	27	7	3	12	17	19	20	22	37	25	20	11	4	1	2	Very regularly graded, fine gravel. Sample coarser than pit average. Has given good service on roads for several years.
209	1¼ m. SW. of Lepreau.	46	54	0	3	8	15	14	26	34	16	13	19	24	17	9	2	Fine, hard gravel, somewhat irregular in size. Very small amount used so far for roads. Apparently good material.

TABLE I—Continued

Results of Physical Tests Upon Gravel Samples—Continued

Sample No.	Location	Granulometric Analysis: Proportion of pebble to sand: Per cent pebble	Per cent sand	Pebble: Per cent retained on screens: 2½"	2"	1½"	1"	¾"	½"	¼"	Sand: Per cent retained on sieves: 8	14	28	48	100	200	Per cent passing 200 mesh	Remarks
210	½ m. NE. of Lepreau.	61	39	7	5	10	21	9	15	33	49	29	14	4	1	1	2	Irregularly graded, medium fine clayey gravel. Per cent of clay and silt of sample (0·7) lower than pit average. Gravel used on roads with very good results.
215	Musquash............	74	26	0	6	13	24	16	17	24	45	25	15	7	3	2	3	Large pit in very irregularly graded gravel, varying in size from very coarse to very fine. Has proved good for roads. Screening is necessary in order to obtain a uniform gravel.
228 (50)	Nashwaak...........	65	35	....	....	....	....	....	....	....	..	..	..	..	....	....	......	Very regular in size and very good for roads; has been used for road surfacing for over two years.
242 (51)	2 m. NE. of Boiestown.	60	40	10	3	7	27	12	18	23	18	14	33	31	4	0	0	Generally coarse gravel, with fairly high proportion of rather coarse sand. Fairly good for roads, although does not compact very hard.
244	Doaktown...........	67	33	0	4	4	22	20	22	28	24	11	24	36	5	0	0	About the same as No. 242, but of better quality, because of being more regular in size and not quite so coarse.
245	½ m. E. of Blissfield..	41	59	0	0	2	12	22	32	32	22	14	30	33	1	0	0	Fine, loose, sandy gravel, regularly graded. Large amount being used for road surfacing. Gravel will take long to compact on account of being very sandy and deficient in binding power. No better material easily available.

248	1½ m. NE. of Blackville. (Underhill's pit).	67	33	14	8	15	23	8	11	21	32	24	25	8	4	4	3	Large pit, partly talus covered; shows regular size gravel in places and sand in others. Sample from a large layer of regularly graded gravel. Gravel very good for road surfacing, if not too much sand intermixed with it.
252	3 m. NE. of Quarryville. (O'Brien's pit)	49	51	0	0	9	33	11	17	30	17	8	25	39	8	2	1	Very regularly graded, medium fine, rather loose, sandy gravel. Used for road surfacing with very good results, although does not possess sufficient binder.
266	3 m. SE. of Tracadie..	......	......	....	....	....	....	....	....	....	..	..	..	..	....	....	......	Fine, hard beach gravel from large bars off the shore. Very good for road surfacing, although takes long to compact. No other suitable material for miles.
287	2 m. NE. of Hopewell Hill.	53	47	0	14	13	17	10	16	30	26	16	13	12	12	8	13	Irregularly sorted material (drift) carrying about 60 per cent of fine sand, silt and clay. Sample coarser than pit average. Gives good service on local light-trafficked roads.
288	Albert (Wallace's pit and Pack's pit).	57	43	0	3	11	15	17	21	33	34	24	21	16	3	1	1	Coarse, and somewhat bouldery, loose gravel. Boulders 5 per cent. Very good for roads.
290	NE. of Germantown..	77	23	10	12	14	19	12	15	18	32	24	17	10	6	4	7	Schist conglomerate, very dusty. Very soft and easily loosened with pick. Makes a very smooth road surface when dry. Unsuitable for durable surfacing, the pebbles crumbling very readily.
311	1 m. N. of Elgin......	53	47	0	13	18	12	12	16	29	30	20	16	12	9	6	7	Medium coarse gravel or drift, with fairly high proportion of sand and 10 per cent boulders. Material varies little in size from place to place. Very good for roads.
317	4 m. NW. of Sussex..	37	63	0	8	14	14	9	17	38	28	27	21	8	4	4	8	Fine, loose, irregularly graded, very soft gravel. Used only on local roads, which carry a very light traffic.
321	2¼ m. SW. of Cumberland Bay.	......	......	....	....	....	....	....	....	....	..	..	..	..	....	....	......	Beach gravel, varying regularly in size from very coarse and bouldery to very fine. Fairly high proportion of sand. Much used for surfacing local roads, carrying light traffic. Makes a very smooth surface, wearing evenly but fast. Only gravel available for miles.
326	3½ m. W. of Chipman.	83	17	11	9	20	19	9	12	20	42	19	17	15	4	1	2	Coarse and regularly graded. Boulders: 10 per cent. Sample slightly coarser than pit average; makes a good and durable road surface, the low percentage of sand being compensated by the high proportion of friable sandstone pebbles.

TABLE I—Concluded

Results of Physical Tests Upon Gravel Samples—Concluded

Sample No.	Location	Granulometric Analysis: Proportion of pebble to sand: Per cent pebble	Per cent sand	Pebble: Per cent retained on screens: 2½"	2"	1½"	1"	¾"	½"	¼"	Sand: Per cent retained on sieves: 8	14	28	48	100	200	Per cent passing 200 mesh	Remarks
335 (52)	6 m. W. of Devon....	44	56	0	0	7	16	18	23	36	25	23	21	15	8	5	3	Fine and regular in size. Used on river road with fairly good results. Compacts well, but does not bind very strongly.
339	2¼ m. NE. of McAdam Junction.	......	......	......	......	......	......	......	......	......	..	..	..	..	......	......	......	Boulders : 5 per cent. Gravel very irregularly sorted as to size, including pockets of sand and silt. Much used for roads. Compacts to a smooth surface, but does not bind hard. All gravels of same character for miles.
344 (49)	1 m. W. of Babbits (Highway Division's pit).	62	38	0	7	6	14	12	19	42	36	26	23	9	3	1	2	Medium fine gravel, very good for road surfacing. Another pit half mile to the east shows softer gravel but also regular in size and suitable for roads.
346 (48)	3 m. NW. of Upper Gagetown.	60	40	0	9	10	29	8	14	30	26	20	25	18	5	2	4	High bank shows gravel varying irregularly from very coarse and bouldery to medium fine. Takes long time to compact on road, but is otherwise quite suitable for road surfacing.
349 (47)	2½ m. W. of Gagetown (Highway Division's pit).	34	66	0	0	0	3	16	27	54	20	23	24	23	5	2	3	Fine, regularly graded gravel, fairly durable on roads with light traffic. Used on local roads with good results. Binds very well.
353	S. of Hamstead......	66	34	3	4	13	27	15	17	21	20	17	17	22	14	4	5	Very loose, soft, regular size gravel. Makes a very smooth road surface, but wears fast and produces dust. Suitable only for light-traffic roads.
359	Grandview..........	62	38	12	6	17	15	10	12	28	32	27	23	12	4	1	1	Regularly graded, coarse gravel, with about 50 per cent of sand. Sample coarser than pit average. Good for road surfacing.

TABLE II

Results of Physical Tests Upon Gravel Samples

Sample No.	Location	Character of material					Abrasion test per cent of wear	Remarks
		Composition of pebbles			Shape of pebbles	Per cent of clay and silt		
		Durable	Intermediate	Soft				
11	2½ m. S. of Dalhousie............	9	88	3	All shapes....	....	4·0	About ⅔ limestone, mostly hard. Very large gravel beach right along the main road.
13	1 m. E. of River Charlo..........	30	27	43	Angular.......	....	13·2	Felsite, trap, metamorphic. Gravel very rusty; large amount available.
35	1½ m. SE. of Bathurst...........	82	18	0	Subangular....	1·0	3·1	Quartzite, granite, syenite, gneiss. Gravel very common for several miles to the south; amount practically unlimited.
45	2½ m. NW. of St. Louis...........	0	5	95	Subangular....	1·5	27·0	Very soft sandstone gravel, forming many shallow deposits between this point and Buctouche.
52	¾ m. SE. of St. Grégoire..........	0	5	95	Rounded......	1·1	29·4	Same as No. 45.
56 (46)	2m. NW. of Memramcook West (Highway Division's pit).	73	6	21	Rounded......	2·9	15·6	Quartz, felsite. Rust and organic matter. Conglomerate, blasted or loosened with pick and used on roads same way as gravel. Very large amount available.
57	2 m. NW. of St. Joseph...........	0	0	100	....	2·0	....	Largely syenite. Intensely weathered rock, apparently conglomerate. Easily loosened with pick and used same as gravel. Very large amount available.
59	S. of College Bridge.............	72	25	3	Rounded......	1·4	12·0	Same as No. 56, except that the proportion of pebbles is not so uniform. Conglomerate thickly covered in places.
64	E. of Aulac (Highway Division's pit).	63	19	18	Rounded......	....	11·9	Quartz, felsite, sandstone. Rust and organic matter. Conglomerate somewhat similar to 56, but much harder to loosen. Cannot be extensively quarried unless occasional sandstone beds are removed. Sandstone easily loosened by blasting.
67	2 m. NE. of River Glade (Power's pit).	40	21	39	All shapes....	0·5	8·0	Granite, sandstone. Much gravel available here; very scarce between here and Moncton.

TABLE II—Continued

Results of Physical Tests Upon Gravel Samples—Continued

Sample No.	Location	Character of material					Abrasion test per cent of wear	Remarks
		Composition of pebbles			Shape of pebbles	Per cent of clay and silt		
		Durable	Intermediate	Soft				
72	1½ m. SW. of Portage	64	12	24	Subangular	1·8	....	Quartz, felsite, syenite, sandstone. Gravel covered with 2 to 3 feet of sand. Binds well on road. Amount available unknown, apparently small.
73	1¾ m. NE. of Kedron	21	30	49	Subangular and flat.	0·3	9·8	Granite, felsite, metamorphic, sandstone. Large amount here and along the bank of Kennebecasis river.
77	S. of Plumweseep	12	39	49	Angular	2·0	7·5	Metamorphic, sandstone. Gravel thickly covered with sand in places. Amount of gravel probably over 50,000 cubic yards.
78	Sussex	73	21	6	Angular	....	3·5	Metamorphic rocks. Large flats of river gravel. Amount unlimited. Deficient in binder.
80	1½ m. W. of Sussex	37	27	36	Angular and flat.	1·6	16·7	Felsite, quartzose, sandstone; coarser pebbles largely sandstone. Very large amount but probably includes much sand.
85	Bloomfield	49	21	30	Angular	....	....	Felsite, quartzose, sandstone. Several large gravel flats along Kennebecasis river.
89	1¾ m. NE. of Rothesay	73	24	3	Angular	8·0	....	Syenite, granite. Drift carrying boulders and pebbles in variable amounts. Very common material for miles.
90	1¼ m. NE. of Rothesay	100	0	0	Angular	....	3·0	All granite. Drift similar to No. 89. Sample of crushed boulders tested for abrasion, same method as for rock. (Table IV.)
94	3 m. SE. of St. John	58	24	18	Angular	1·5	5·5	Igneous and metamorphic rocks. Loose gravel. Upper 2 feet of bank weathered. Over 100,000 cubic yards of gravel available.
98	1¼ m. SE. of Westfield Station	39	49	12	Subangular	0·7	....	Quartzose and schistose metamorphic. Very large amount of gravel available, but probably includes much sand. Does not bind readily.

99	Woodmore Point..............	61	21	18	Angular.......	0·6	7·4	Igneous and metamorphic rocks. Gravel somewhat rusty. Fairly large amount available.
102	3 m. SE. of Welsford.............	46	36	18	Subangular and flat.	1·0	4·9	Largely metamorphic rocks. Loose gravel found for several hundred yards along road. Deficient in binder.
105	½ m. SE. of Welsford (Thomson's pit).	58	30	12	Subangular....	0·1	....	Igneous and metamorphic rocks. Amount of gravel unknown, probably large, but most of it is too fine.
113	4 m. S. of Oromocto (Highway Division's pit).	49	33	18	Subangular and some flat.	0·5	....	Igneous and metamorphic rocks. Depth of gravel not over 2½ yards. Deposit apparently extends over several acres.
118	3 m. NE. of Pokiok.............	58	33	9	Subangular....	0·9	4·0	Largely metamorphic rocks. Long ridge running parallel to road. Unlimited amount of gravel.
121 (57)	1 m. W. of Allandale (Grant's pit).	52	36	12	Subangular....	0·8	....	Largely metamorphic. Some limestone. Gravel thickly covered with sand in places. Over 25,000 cubic yards of gravel available without much stripping.
123	½ m. W. of Meductic (Highway Division's pit).	46	36	18	All shapes....	2·3	6·4	Metamorphic, sandstone. This gravel is found for several miles along road and is everywhere very irregular in size of particles.
124 (58)	1 m. N. of Lower Woodstock (Highway Division's pit).	46	24	30	Subangular....	3·0	....	Metamorphic, limestone, calcareous slate. Gravel very common for miles along the St. John river, and everywhere very irregularly graded. Binds very well on roads.
126 (59)	1½ m. W. of Woodstock (Highway Division's pit).	25	35	40	Subangular....	1·0	5·1	Metamorphic, limestone, calcareous slate. Old railway pit in large deposit of irregularly graded gravel. West of here gravel is very scarce.
127	5 m. S. of Hartland (Highway Division's pit).	9	58	33	Subangular and flat.	4·0	10·8	Largely calcareous slate and limestone. About the same as No. 124.
129 (60)	2 m. N. of Hartland.............	15	55	30	Angular.......	2·0	8·9	Largely calcareous slate and limestone. Pebbles coated with $CaCO_3$. About the same as No. 124.
131	1¼ m. NW. of Riverbank........	18	33	49	Subangular and flat.	2·0	4·8	Metamorphic, limestone, calcareous slate, sandstone. Overburden 1½ feet to 2½ feet of clayey loam. Fairly large amount available; also large flats of stream gravel along the St. John river.
139 (61)	2 m. S. of Perth (Highway Division's pit).	12	67	21	Subangular....	0·2	2·6	Mostly limestone, some slaty. Depth of deposit 20 feet. Extent unknown but apparently very large amount of gravel available.

TABLE II—Continued

Results of Physical Tests Upon Gravel Samples—Continued

Sample No.	Location	Character of material: Composition of pebbles: Durable	Intermediate	Soft	Shape of pebbles	Per cent of clay and silt	Abrasion test per cent of wear	Remarks
145	2¾ m. S. of Grand Falls..........	0	18	82	Flat..........	2·6	16·7	Largely slate. Upper 2 feet of gravel weathered and rusty. Fairly large deposit along ruisseau des Femmes.
149 (53)	2 m. SE. of Newmarket (Highway Division's pit).	21	18	61	Angular......	2·7	....	Largely schistose metamorphic. Amount of gravel available over 20,000 cubic yards.
150	3 m. SE. of Newmarket.........	0	80	20	Subangular and some flat.	4·2	....	Largely metamorphic rocks. Conglomerate and sandstone seen in road cuts between here and No. 151. Covered with 1½ to 2½ feet of drift. Conglomerate too hard to be worked loose with pick.
151 (54)	4½ m. S. of Newmarket (Highway Division's pit).	40	27	33	Angular......	3·5	11·9	Metamorphic, sandstone. Deposit apparently not more than 6 feet deep; extends over several acres. Amount of gravel available unknown.
154 (55)	1 m. SE. of Thomaston..........	52	21	27	All shapes....	0·5	10·6	Quartzose, granite, sandstone. Several deposits. Probably over 100,000 cubic yards available.
157	1½ m. N. of Brockway...........	27	52	21	Angular......	1·2	7·2	About ⅔ sandstone, fairly hard. Large gravel ridge, probably very sandy in places.
163	4¼ m. N. of St. Stephen..........	55	24	21	Angular and flat.	0·8	8·1	Over ⅔ metamorphic rocks. Deposit 10 feet deep. Amount of gravel available unknown, probably over 10,000 cubic yards.
166	3 m. N. of St. Stephen (Hay's pit)	40	35	25	Subangular....	1·0	....	Largely metamorphic rocks. Weathering down to 5 feet. Amount of gravel available about 20,000 cubic yards, most of it very fine.
168	3 m. NE of St. Stephen..........	46	33	21	Angular and flat.	1·7	13·2	Largely metamorphic rocks. Several large deposits, probably over 50,000 cubic yards of gravel available. Binds fairly well on road.
169	S. of Oak Bay (Young's pit)....	43	30	27	Angular......	1·6	9·9	Same as No. 168, but more regularly graded here.

171	3 m. SE. of Oak Bay............	33	49	18	Flat and angular.	1·0	5·5	Largely metamorphic rocks. Rusty gravel, binding well on road. About 15,000 cubic yards already taken out and 10,000 cubic yards still available.
175	3½ m. W. of Bocabec.............	79	18	3	Angular.......	1·8	3·6	Granite, syenite, trap, metamorphic. Over 10,000 cubic yards of gravel available.
181	Bocabec.........................	61	24	15	Angular.......	1·4	3·6	Granite, diorite, metamorphic. Amount available unknown, probably large. Banks of brook gravelly on surface.
184	5 m. NW. of St. George..........	76	18	6	Angular.......	1·3	5·5	Largely metamorphic rocks, also some granite and felsite. Amount of gravel available over 50,000 cubic yards, including possibly much sand.
189	2⅔ m. NW. of St. George.........	95	5	0	All shapes....	7·5	....	Largely felsite, somewhat glassy. Drift deposit, showing a few layers of gravelly sand. Amount of gravel probably very small.
190	2 m. NW. of St. George..........	100	0	0	Angular.......	0·7	1·8	Felsite, granite, all very hard. Deposit forms small steep-sloped knoll, over 10,000 cubic yards in size. Gravel is very hard and devoid of binder.
197	1½ m. E. of St. George...........	73	21	6	Subangular....	7·0	2·8	Felsite, metamorphic, trap. Amount of gravel available apparently very large.
200	½ m. E. of Pennfield Centre......	55	30	15	Angular and flat.	0·7	7·2	Felsite, metamorphic trap. Small ridge covering over 2 acres. Amount of gravel over 15,000 cubic yards.
209	1¼ m. SW. of Lepreau............	70	30	0	Angular.......	1·0	....	Granite, syenite, schist, gneiss. Gravel deposit forms low hump, very sandy on surface. Many similar humps found for several miles. Amount of gravel unknown.
210	½ m. NE. of Lepreau.............	61	33	6	Angular.......	0·7	6·4	Igneous and metamorphic rocks. Per cent of clay and silt of sample (0·7) lower than pit average. Amount of gravel available over 3,000 cubic yards, probably much larger.
215	Musquash........................	76	18	6	Angular.......	1·0	4·4	Granite, schist, diorite, felsite. Per cent of clay and silt of sample (1·0) lower than pit average. Amount of gravel very large but includes a high proportion of sand and boulders.
228 (50)	Nashwaak.......................	60	18	22	Subangular....	....	3·7	Metamorphic, sandstone. Small deposit about 2,000 cubic yards in size.
242 (51)	2 m. NE. of Boiestown..........	70	20	10	Subangular....	0·1	3·5	Metamorphic, felsite, granite, sandstone. Several large deposits between Boiestown and Ludlow. Unlimited amount of gravel available.

TABLE II—Concluded

Results of Physical Tests Upon Gravel Samples—Concluded

Sample No.	Location	Character of material: Composition of pebbles: Durable	Intermediate	Soft	Shape of pebbles	Per cent of clay and silt	Abrasion test per cent of wear	Remarks
244	Doaktown	67	24	9	Subangular	0·1	5·1	Granite, syenite, metamorphic, sandstone. Several deposits in the form of low humps or ridges. Large amount of gravel.
245	½ m. E. of Blissfield	55	18	27	Subangular	0·0	....	Granite, felsite, sandstone. Gravel bluff facing Miramichi river. Depth of deposit at least 15 feet and very large amount of gravel available.
248	1½ m. NE. of Blackville (Underhill's pit).	40	20	40	Angular to rounded.	1·0	8·7	Granite, syenite (angular), sandstone (rounded). Gravel clayey in places. Sand deposit carrying large layers or pockets of regular size gravel.
252	3 m. NE. of Quarryville (O'Brien's pit).	49	24	27	Subangular	0·7	11·5	Granite, syenite, metamorphic, sandstone, the latter over 40 per cent of total. Over 10,000 cubic yards of gravel available.
266	3 m. SE. of Tracadie	80	20	0	Subangular	0·0	....	Quartzite, felsite, trap, limestone, sandstone. Large gravel bars off shore. Hauled by wagons at low tide.
287	2 m. NE. of Hopewell Hill	50	30	20	Angular	7·9	....	Syenite, felsite, sandstone. High bluff facing Shepody bay, and composed of drift material.
288	Albert (Wallace's pit and Pack's pit).	85	15	0	Angular and flat.	0·3	6·9	Granite, gneiss, felsite, schist. Gravel deposit forms high bluff. Probably over 100,000 cubic yards of gravel available.
290	NE. of Germantown	0	10	90	Angular and flat.	1·5	....	Green and purple schist, very friable and crumbling readily on road into very fine dust. Dusty purple schist conglomerate, forming high bluff along road. Amount practically unlimited.
311	1 m. N. of Elgin	75	22	3	Angular and some flat.	3·4	9·6	Largely metamorphic. Looks like partly water-sorted drift, very regular in size. Deposit forms several small knolls. Over 50,000 cubic yards available.

31	4 m. NW. of Sussex	15	20	65	Subangular	5·0	....	Over 75 per cent sandstone, most of it very soft. Gravelly ridge. Probably over 50,000 cubic yards of gravel.
321	2¼ m. SW. of Cumberland Bay	0	25	75	Subangular and flat.	....	8·1	All Carboniferous sandstone. Beach gravel found at several points along shore of Grand lake. Very large amount available. Bank gravel very scarce.
326	3½ m. W. of Chipman	15	45	40	Subangular and flat.	0·8	7·6	About ⅓ dolerite and ⅔ sandstone. Binds well on road. Amount of gravel uncertain, probably very large, judging from surface indications. Gravel bouldery; boulders should be screened out.
335 (52)	6 m. W. of Devon	50	5	45	Subangular	1·7	....	Quartz, sandstone. Gravel deposit covered with 3 feet of loamy silt. Amount of gravel very large. Poor binding quality.
339	2¼ m. NE. of McAdam Junction	76	18	6	Angular	Much silt	8·7	Over 80 per cent granite, most of it not very hard. Gravel deposit covered with 1 to 5 feet of sand. Amount very large. Boulders should be screened out.
344 (49)	1 m. W. of Babbits (Highway Division's pit).	64	24	12	Angular	0·7	....	Metamorphic, felsite, sandstone. Depth of deposit 6 feet; extent unknown. Deposit covered with bush. Amount of gravel available apparently large. Another pit, ½ mile east of here shows similar gravel but much softer. 50 per cent soft pebbles.
346 (48)	3 m. NW. of Upper Gagetown	50	15	35	Subangular	1·4	5·3	Quartzite, felsite, sandstone. Large gravel ridge over 3 miles in length. Millions of cubic yards available along road.
349 (47)	2½ m. W. of Gagetown (Highway Division's pit).	35	15	50	Angular	1·8	....	Quartzite, felsite, sandstone, the latter about 50 per cent of total. Flat deposit, apparently not more than 6 feet deep. Amount of gravel available over 15,000 cubic yards.
353	S. of Hamstead	21	27	52	Subangular and flat.	2·6	....	Largely metamorphic rocks, most of them slaty or schistose and rather soft. Deposit forms round knoll containing over 10,000 cubic yards.
359	Grandview	52	27	21	Angular and flat.	0·6	7·0	Dolerite or trap, felsite, slate. Several pits in flank and top of hill. Amount of gravel available very large.

TABLE III

Results of Physical Tests Upon Gravel Samples

Sample No.	Fineness modulus	Sand mortar: 1 cement; 3 sand					Remarks
		Per cent of water used	Tensile strength, per cent of standard		Compressive strength, per cent of standard		
			7 days	28 days	7 days	28 days	
35	2·61	14	86	79	91	98	Percentage retained on 48 mesh much too high.
56 (46)	3·32	21	0	39	0	21	Too much iron oxide and clay; had not set in 7 days.
73	3·42	12	107	101	130	148	Percentage of silt low; small amount of vegetable matter.
80	2·82	14	121	141	136	129	Rather fine brown sand, with small amount of vegetable matter.
94	3·79	13	92	111	107	120	Coarse sand, with large proportion of soft, flat grains.
123	3·93	13	171	164	115	148	Too coarse, and carrying large proportion of soft schistose grains. Suitable.
127	3·36	15	160	155	143	134	Moderate amount of calcareous clay. Suitable.
139 (61)	2·96	13	136	181	155	211	Hard limestone sand, irregularly graded, but suitable.
145	3·00	15	127	130	117	123	Large proportion of soft grains. Suitable.
157	3·24	13	108	91	116	130	Irregularly graded, and does not carry enough fine material.
168	3·41	15	106	109	109	129	Sand grains hard and angular; large proportion of quartz.
175	3·69	15	0	35	0	16	Very coarse and clayey. Had not set in 7 days.
190	2·57	13	127	125	126	124	Sand grains angular and very hard; fairly large proportion of quartz.
244	3·13	13	74	75	93	96	Percentage retained on 48 mesh too high; on finer sieves too low.
248	3·51	13	133	119	161	157	Large proportion of quartz grains and small amount of clay.
311	3·11	15	123	131	124	134	Rather fine sand, carrying small amount of clay.
359	3·65	12	86	89	107	117	Percentage retained on 100 mesh and finer, too small.

BEDROCK

The following description of rocks will be confined to those outcrops lying along or close to the main highways, since they are the only ones of immediate importance to the road builder. Very little bedrock has yet been used in the surfacing of provincial highways, but on account of the great importance of this kind of material in the building of the more permanent types of roadways, it was deemed advisable to examine all outcrops that looked promising as a source of road metal.

Large trappean masses are exposed at many points along Chaleur bay between Campbellton and Bathurst. The same rock is also seen at several places around Fredericton and between St. Stephen and St. George. The rock, which is very dark greenish or purplish grey in colour, is generally fresh and on account of its many cliff-like exposures and regular vertical fracturing, should be very easy to quarry. It is a very good stone and easily available at several places between Campbellton and Dalhousie (Table IV, Nos. 6, 8), at Black Land and Black Point (No. 17), west of Fredericton (No. 336), north of St. Andrews (No. 173), and near Bocabec (No. 176). The amygdaloidal trap, northwest of Fredericton (No. 334), and the coarsely porphyritic trap at Fairley, along the Miramichi river (No. 239), are suitable, although more or less weathered. The large outcrop at Devereaux, along the Campbellton-Bathurst highway, shows a much fractured trap holding many inclusions of altered sedimentary rocks. It is unfit for use in roadwork.

Dikes or sheets of trap, largely diabase, are found at a point along Jacquet river, 3 miles south of the Campbellton-Bathurst highway (No. 18), south of Hamstead (No. 355), at West St. John (No. 96), and west of Bocabec (No. 178). All but the last named are exposed in steep faces, and can be easily quarried in large amount. As seen from Table IV, all are good, durable stones.

Felsites, under which name are included here rhyolites, trachytes, rhyolite-porphyries and syenite-porphyries, are exposed south and west of Campbellton (Nos. 4, 5), southwest of Dalhousie (No. 9), 3 miles south of the main highway at Jacquet River (No. 19), near Harvey Station (No. 152), and at several places between St. Andrews and St. George (Nos. 177, 186). Like the trap, this rock where exposed, usually forms prominent elevations, with steep slopes and occasional cliffs, and shows numerous fracture planes. It is relatively easy to quarry. When fresh this rock is one of the hardest and toughest, and even when partly weathered, it compares favourably as road metal with the best sedimentary rocks of the province. Among the several above-mentioned exposures, No. 4 is the only one showing unsuitable material though the sample collected there represents only the surface rock, which is much weathered and very porous.

Granite occupies considerable areas near Bathurst (No. 33), Hamstead (No. 354), Welsford and St. George (Nos. 193, 194, 195). The Welsford granite was not sampled, owing to the difficulty of obtaining fresh stone. The Bathurst, Hamstead and St. George granites possess all the qualities required in a paving block, but the Hamstead stone is the only one suitable as road metal in macadam construction, the others not possessing a high enough toughness for that purpose. The Hamstead granite is largely quarried for paving blocks and monuments, the St.

George stone for monumental and ornamental purposes. The Bathurst quarries are at present idle.

Carboniferous sandstone underlies nearly the whole eastern half of New Brunswick, and presents numerous small exposures along the main highways, and larger ones along the gulf coast and in the steep banks of many streams. This stone was extensively quarried in the past for building purposes, but most of the quarries have been idle for several years. The only large quarries still in operation are at Quarryville (Miramichi Quarry Co.: pulpstone, millstone, building) and at Stonehaven (Reid Stone Co.: grindstones of all sizes). The stone is much too soft and friable for macadam purposes (Nos. 55, 63). Silurian sandstone is very common both in the north and south parts of the province. It is not generally a good road metal, but an altered phase of the stone, found near the contact with trap intrusions, along the bay of Chaleur (No. 25) and close to the bay of Fundy (No. 182), should prove a good road stone judging from the results of laboratory tests. This altered sandstone is comparatively scarce, and, moreover, its importance is somewhat lessened by the fact that it is found only in close proximity to large masses of trap, the latter being a more durable stone than the altered sediment.

Limestone is fairly common throughout the St. John valley and along Chaleur bay. A crystalline limestone, which forms prominent ridges in and around the city of St. John, has been extensively quarried both for road and lime-making purposes. The laboratory tests on Nos. 91 and 95 show that it does not possess sufficient toughness although No. 95 is suitable for light-trafficked roads.

In dealing with the suitability of the rocks for road construction, waterbound macadam was not taken into consideration, since this type of construction for main roads subjected to a high proportion of automobile traffic has been now nearly completely discarded. In this connexion it may be said that the cementing value of a rock, which had some importance in waterbound macadam, is not considered in roads where an artificial binder is used. It has been retained in the table as an indication of the degree of alteration of the feldspar-bearing rocks, such as the felsites, traps, granites, and Carboniferous sandstones. It is generally found that a feldspar-bearing rock has a lower cementing power when fresh than when more or less altered by weathering agents. Under the same conditions of traffic, waterbound macadam will require a rock having a somewhat greater resistance to wear and impact than in the case of the more permanent types of surfaces.

NOVA SCOTIA

The work in Nova Scotia consisted in making a thorough inspection of the territory on both sides of the Oxford-Wentworth section of the Amherst-Truro highway, and also the territory on both sides of the Amherst-Pugwash section of the Amherst-Pictou highway. In the field work conducted in 1923, along these two sections, no durable material whatever could be found, so the problem was to make use of any local material that might temporarily improve the surface of the main roads, pending the time when the amount of traffic would justify the heavy expense of bringing in more suitable material from outside sources.

All stony deposits lying within hauling distance of the Oxford-Wentworth road were carefully examined, and the ones that appeared more promising as a source of road metal, were immediately reported to the road engineer of the district, Mr. F. G. Crawley of Oxford. Along the Amherst-Pugwash road, nothing was found but a few small outcrops of fine-grained, very friable sandstone. It was thought that if coarse sand or sandstone could be located in the district, it could be used in the building of a good sand-clay surface, which would greatly improve existing road conditions, but no such sand or sandstone could be found. The soil in the eastern part of the Amherst-Pugwash road is largely clay, and in the western part largely fine sand, too fine in fact to produce satisfactory results in a sand-clay mixture. Under such conditions, sandstone from Wallace (No. 543) and limestone from Pugwash (No. 545) will be used in macadamizing the main road as far as it will be practicable to haul it. Both stones are suitable road metals under conditions of light traffic, but the durability of road surfaces built with either of these rocks will be greatly increased if some sort of bituminous top dressing be added.

QUEBEC

While passing through this province on the way back to Ottawa, nine stone quarries were visited and sampled. There are numerous outcrops of Trenton limestone north of the St. Lawrence river between Joliette and Quebec. The stone has been extensively quarried for years and the product used either for making lime or as road metal. Stone of the same formation is also very common in the Montreal and Ottawa districts, and several quarries from both districts were sampled for testing in 1915 and 1917. The results were published in the Geological Survey reports: Memoir 99: "Road Material Surveys in 1915," by L. Reinecke, and Memoir 114: "Road Material Surveys in the City and District of Montreal, Quebec," by Henri Gauthier. It was deemed advisable to collect samples from the more important quarries in the Joliette-Quebec area, so as to ascertain any variation in the road-making qualities of the rock, as compared with the Montreal and Ottawa stones. The five samples tested (Nos. 485, 486, 487, 489, 490) show that the stone is suitable for macadam work on roads subjected to a comparatively light traffic. It is not appreciably different from the Montreal stone, but is slightly harder than the Ottawa stone. Sillery sandstone has been lately quarried for road purposes near the cities of Quebec and Levis (Nos. 484, 488). It is a more durable stone than the local limestone and can be safely used in bituminous macadam pavements, even under heavy traffic. A waterbound macadam built of finely crystalline syenite near St. Johns failed after a short time. Due to the very low cementing power of the stone, the fast automobile traffic disrupted the road surface before this stone had shown any appreciable wear. As seen from the test (No. 483), it is a hard and tough stone, and should give very good results in road surfacing if used with the addition of an artificial binder. The Chazy limestone from Grande Ligne, near St. Johns, (No. 491), is as good as the Trenton limestone for road material, perhaps slightly less durable on account of its less uniform texture.

TABLE IV
Results of Tests Upon Bedrock

No.	Location	Rock type	Physical Properties: Wear, per cent	French co-efficient of wear	Toughness	Hardness	Cementing value	Specific gravity	Water absorbed, lbs. per cu. ft.	Remarks
	New Brunswick									
4	1 m. W. of Campbellton.	Rhyolite-porphyry..	4·10	9·8	....	....	400+	2·59	6·34	Sample of weathered surface rock. Very high cementing power due to weathering.
5	Campbellton (Sugar Loaf).	Felsite............	1·99	20·1	25	18·7	25	2·60	0·32	Sound glassy rock, from foot of cliff.
6	5 m. E. of Campbellton..	Dolerite...........	3·12	12·8	11	17·6	400+	2·66	1·98	Sample of partly weathered rock from bay shore.
8	$1\frac{2}{3}$ m. W. of Dalhousie (Montgomery's quarry)	Dolerite...........	2·36	17·0	16	18·2	262	2·74	1·14	Old quarry.
9	$3\frac{1}{4}$ m. SW. of Dalhousie..	Dolerite...........	2·54	15·7	....	....	221	2·72	1·33	Sample taken from talus. Rock partly weathered.
17	Black Point............	Dolerite...........	2·46	16·3	17	16·8	173	2·73	0·70	
18	3 m. SW. of Jacquet River.	Diabase...........	2·76	14·5	14	16·4	375+	2·77	1·41	Sample taken from talus. Rock partly weathered.
19	3 m. SW. of Jacquet River.	Syenite-porphyry...	3·18	12·6	18	17·1	350+	2·79	3·45	Weathered rock.
25	$2\frac{1}{2}$ m. SE. of Belledune..	Ferruginous sandstone (Silurian).	2·74	14·6	17	19·1	100	2·77	0·96	
33	4 m. S. of Bathurst (Connolly's quarry).	Granite...........	3·08	13·0	9	18·9	39	2·65	0·45	
55	$1\frac{3}{4}$ m. S. of Shediac (Smith's quarry).	Sandstone (Carboniferous).	9·80	4·1	3	10·4	127	2·52	7·39	
63	Wood Point............	Sandstone (Carboniferous).	8·07	5·0	5	12·6	225	2·55	6·45	Old quarry.
90	$1\frac{1}{4}$ m. NE of Rothesay..	Granite...........	3·00	13·3	....	....	80	....	....	Drift boulders.
91	Brookville (Provincial Lime Co.'s quarry).	Crystalline limestone (Precambrian.	4·61	8·7	4	12·9	100	2·71	0·23	
95	Douglas St., St. John (Murray and Gregory's quarry).	Crystalline limestone (Precambrian.	2·91	13·7	9	16·6	47	2·71	0·13	
96	West St. John..........	Trap..............	2·01	19·9	15	18·5	69	2·79	0·29	
152	$1\frac{1}{2}$ m. SW. of Harvey station.	Rhyolite..........	1·86	21·5	20	19·3	67	2·62	1·03	
173	4 m. NW. of St. Andrews	Dolerite...........	2·30	17·4	16	19·2	59	2·73	0·30	
176	3 m. W. of Bocabec....	Diabase...........	2·18	18·3	37	19·2	41	2·96	0·19	

177	3 m. W. of Bocabec......	Trachyte..........	1·53	26·1	29	19·3	43	2·76	0·34	
178	2 m. W. of Bocabec......	Diabase...........	2·30	17·4	16	17·9	78	2·95	0·33	
182	1 m. E. of Bocabec......	Sandstone (Silurian)	2·46	16·3	21	18·1	30	2·74	0·58	
186	4 m. NW. of St. George.	Syenite-porphyry...	1·86	21·5	31	19·3	36	2·64	0·44	
193	2¾ m. NW. of St. George	Granite............	2·79	14·3	8	19·3	29	2·62	0·64	
194	½ m. N. of Bonny River station (McGratton's quarry).	Granite............	4·32	9·3	7	19·1	22	2·63	0·60	
195	2½ m. N. of St. George..	Granite............	2·42	16·5	7	19·2	31	2·61	0·53	
239	Fairley................	Trap-porphyry......	2·70	14·8	12	16·5	169	2·90	1·75	
334	2 m. NW. of Nashwaaksis (City of Fredericton quarry).	Trap...............	3·32	12·0	14	16·5	350+	2·87	3·11	Partly weathered.
336	6 m. W. of Devon.......	Trap...............	2·20	18·2	32	18·4	88	2·91	0·45	
354	Hamstead (Granite Street Paving and Construction Co.'s quarry).	Granite............	2·06	19·4	13	18·8	35	2·70	0·41	
355	5 m. NE. of Oak Point..	Diabase...........	1·45	27·6	26	19·0	33	2·90	0·39	
	Quebec									
487	NE. of Chateau Richer (Gravel's quarry).	Limestone (Trenton).	3·73	10·7	8	16·6	96	2·70	0·10	
486	Giffard (Verreault's quarry).	Limestone (Trenton)	3·98	10·1	5 10	16·1 17·0	177	2·69	0·17	Quarry shows some beds tougher and harder than the average. Limestone shaly.
485	Charlebourg (Pagé's quarry).	Limestone (Trenton)	4·24	9·4	8	16·7	136	2·69	0·30	Limestone shaly.
484	Sillery (Vézina's quarry)	Sandstone (Sillery).	3·96	10·1	15	18·7	300+	2·70	0·99	
488	S. of Lévis (Blais' quarry).	Sandstone (Sillery).	2·77	14·4	11	18·9	147	2·69	0·58	
490	St. Louis de France (St. Maurice Lime Co.'s quarry).	Limestone (Trenton)	3·74	10·7	8	15·4	172	2·71	0·53	Limestone shaly.
489	SW. of Joliette (Standard Lime Co.'s quarry	Limestone (Trenton)	4·38	9·1	6	13·9	125	2·70	0·43	
483	Near St. Johns (Baillargeon's quarry).	Syenite............	2·12	18·9	15	18·3	20	2·49	1·71	
491	Grande Ligne, near St. Johns.	Limestone (Chazy).	4·20	9·5	7	14·2	77	2·75	0·58	
	Nova Scotia									
543	Wallace (Wallace Sandstone Quarries).	Sandstone (Carboniferous).	3·32	12·0	6	10·5	82	2·55	5·73	
545	3 m. SW. of Pugwash (Nova Scotia Clay Works' quarry).	Limestone (Carboniferous).	2·94	13·6	11	16·5	81	2·70	0·65	