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REPORT ON MINING OPERATIONS IN THE PROVINCE OF QUEBEC DURING THE YEAR 1916

PROVINCE OF QUEBEC, CANADA

Department of Colonization, Mines and Fisheries

MINES BRANCH

Honourable HONORÉ MERCIER, Minister : : S. DUFAULT, Deputy-Minister

THÉO. C. DENIS, Superintendent of Mines

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Province of Quebec.

DEPARTMENT OF COLONIZATION, MINES AND FISHERIES.

To the HONOURABLE HONORÉ MERCIER,
Minister of Colonization, Mines and Fisheries,
Quebec.

SIR,—

I have the honour to transmit the "Report on Mining Operations in the Province of Quebec during the year 1916," prepared by the Mines Branch of your Department.

I have the honour to be,

Sir,

Your obedient servant,

S. DUFAULT,
Deputy Minister.

Quebec, May 22nd, 1917.

Province of Quebec.

DEPARTMENT OF COLONIZATION, MINES AND FISHERIES.

MINES BRANCH

S. Dufault, Esq.,

Deputy-Minister of Colonization,
Mines and Fisheries, Quebec.

Sir,—

I beg to submit the Report on Mining Operations in the Province of Quebec during the year 1916. The statistical review of the mineral production is followed by notes on the development of the mineral industry during the year. A full report is given of the accidents which occurred in the mines during the twelve months of 1916, also Dr. J. A. Bancroft's report on the geology and the mineral resources along the Transcontinental Railway, northwest of Quebec city.

The figures given in the Preliminary statement on the mineral production, published in February 1917, are superseded by the revised figures given in this report.

Your obedient servant,

THÉO. C. DENIS,
Superintendent of Mines.

Quebec, May 22nd, 1917.

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NOTE.

In the statistical tables and in the review of the mining industry of the province during the year, the term "production" is synonymous with "quantity sold or shipped," and does not necessarily represent "output." The ore, and other mineral products remaining as "Stock on hand" at the end of the year, are not included in the production figures.

The ton used throughout is that of 2,000 lbs., except when specially mentioned.

The year referred to is the calendar year, ending December 31st, unless specially stated.

We endeavour to give values of the mineral products, raw or manufactured, as estimated at the point of shipment or at the pit-mouth; this, however, is sometimes difficult to obtain.

MINING OPERATIONS
IN
THE PROVINCE OF QUEBEC
DURING THE CALENDAR YEAR 1916

STATISTICAL REVIEW

The total value of the mineral production of the Province of Quebec in 1916 reached $13,287,024. Of this the building materials represent a value of $5,278,486, and the products of the mines proper figure for $8,008,538. In 1915 the total value was $11,465,-873, divided as follows: products of the mines $5,223,639, and building materials $6,242,234.

The increase in the total for 1916, as compared with 1915 is therefore 15.9%. The produce of the mines show an increase of 53.3% and the building materials a decrease of 15.4%.

Both the mining industry and the metallurgy in the Province of Quebec have been greatly stimulated by the intensive production of war materials. The supply of asbestos, chromite, magnesite, copper ores, molybdenite, has not been equal to the demand and prices have increased greatly. Asbestos Crude No. 1 which in 1913 averaged a value of $275 a ton, reached an average of $423 in 1916; chromite which before the war sold for $14 a ton on the New York market is now quoted $45; copper in December 1916 was quoted 33c. a lb; molybdenite has quadrupled in price in three years, and all these substances are produced in the Province of Quebec.

The metallurgical industry has also greatly benefitted by the manufacture of munitions and war material. In the last three years a large number of steel furnaces have been installed, among which are several electric ones. The development of the electric steel furnace may be judged from the fact that in 1915, only 61 tons of steel ingots and castings were reported as having been made in Canada in electric furnaces, whereas in 1916 the production reached 43,790 tons.[1]

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[1]Preliminary report on the mineral production of Canada in 1916, Department of Mines, Ottawa.

The production of aluminium, from imported ores, has also been pushed actively. The only aluminium reduction works in Canada are situated at Shawinigan Falls and are operated by the Northern Aluminum Co.

Metallic magnesium is also being manufactured at Shawinigan Falls.

The most serious impediment to a greater production of the mines of the Province of Quebec has been the great shortage of labour. As an illustration of this it may be mentioned that in the asbestos district alone the mines could have employed 800 more men than they could find. Wages rose accordingly and from the low ebb price of $1.25 a day in the spring of 1915, when mines were either closing down, or greatly reducing their operations, they have now attained $2.50 for labour of an average inferior quality owing to the gaps made by enlistment for active service.

On the other hand, the present economic conditions are detrimental to the building materials industry, and whereas in 1914 the products of clay pits and stone quarries constituted more than 65% of our total mineral production, in 1916 they figured for only 39%.

The following table presents the total figures of the mineral production of the Province of Quebec for each year for the last 17 years:

YEAR	VALUE	YEAR	VALUE
1900	$ 2,546,076	1909	$ 5,552,062
1901	2,997,731	1910	7,323,281
1902	2,985,463	1911	8,679,786
1903	2,772,762	1912	11,187,110
1904	3,023,568	1913	13,119,811
1905	3,750,300	1914	11,732,783
1906	5,019,932	1915	11,465,873
1907	5,391,368	1916	13,287,024
1908	5,458,998		

The table shows that the value of the mineral production for the year 1916, is the highest on record, being $167,213, more than in 1913 which was previously the banner year. It is very gratifying to note the progress made by the figures of the value of the products of the mines in the last three years, leaving aside the building materials. We find that in 1913 the value of the products of the mines amounted to $4,931,894, whereas in 1916 this had increased to $8,008,538, an advance of 62.4%. On the other hand the building materials have fallen off from $8,186,917 to $5,278,486, or a proportional decrease of 35%. This diminution in the structural materials is due to the economic conditions which have prevailed since the beginning of the war, in August 1914. In all probability the figures will resume their former importance when normal conditions are restored.

TABLE OF MINERAL PRODUCTION OF THE PROVINCE OF QUEBEC DURING 1916

SUBSTANCES	No. of Work-men	Salaries	Quantities	Value	Value in 1915
		$		$	$
Asbestos, tons	2,846	1,652,976	133,339	5,182,905	3,544,362
Asbestic, tons	......	....	20,710	28,252	21,819
Chromite, tons	302	142,497	27,952	312,901	245,297
Copper and Sulphur ore, tons	304	208,931	131,017	1,259,064	1,021,777
Feldspar, tons	......	....	4,606	20,760	640
Glass Sand, tons	32	14,125	11,351	24,140	8,000
Gold, ozs	25	1,893	632	13,041	23,082
Graphite, lbs	125	57,916	957,100	75,776	2,461
Kaolin, tons	42	25,000	1,750	17,500	13,000
Magnesite, tons	191	243,850	53,976	525,966	137,353
Mica, lbs	172	56,345	1,435,924	177,814	55,897
Mineral Waters, gals	19	7,114	115,210	18,574	33,084
Mineral Paint (ochre), tons	101	33,266	8,768	62,875	42,285
Molybdenite, lbs	156	61,961	129,275	129,267	....
Phosphate, Titaniferous Iron and Quartz, tons	24	7,401	4,978	14,242	2,400
Silver, ozs	......	....	58,044	38,113	36,182
Zinc and Lead (Ores) tons	139	92,715	3,401	107,348	36,000
STRUCTURAL MATERIALS					
Brick, M	672	296,877	112,049	762,689	655,017
Cement, bbls	518	463,131	2,150,457	2,525,841	2,805,374
Granite	495	225,923	....	292,270	269,350
Lime, bush	296	109,622	1,267,590	276,245	228,670
Limestone and Marble	1,475	584,298	....	978,945	1,830,141
Sand	120	51,551	....	168,891	210,809
Sandstone, tons	24	6,226	1,638	8,190	35,754
Slate, Sq	22	11,085	1,261	6,223	2,039
Tile, Drain and Sewer Pipe, Pottery, etc	163	92,590	....	259,192	195,080
	8,263	4,447,293	....	13,287,024	11,465,873

MINING VENTURES AND THE PUBLIC

At various times warnings have been issued through the pages of the Annual Report of the Quebec Mines Branch guarding the investing public against the purchase of share certificates, in mining ventures of which they know nothing personally and on which the only information they possess are the glowing statements of agents, whose only aim is to sell as much of the stock as possible.

To achieve this object the promises and predictions of the peddlers of shares and unscrupulous promoters are usually as enticing as they are visionary, but they make numerous victims, more especially in the rural communities, and among the urban people of small means.

The investing public should discriminate between "mines," and "prospects." Some producing mines, or mines well developed, constitute as safe an investment as any other commercial and industrial entreprise, but these rarely yield more than a fair return. On the other hand, "prospecting" and "developing," be it for ores, for natural gas, for oil, are naturally hazardous ventures. When successful, the returns from such investments are large, but failures are infinitely more numerous than successes. Such investments are not for the small savings, which should always remember that the risk is proportionate to the returns. If the investor expects large returns he has to take risks of losses. And before buying shares in companies searching for, or developing, deposits of gold, lead, zinc or other minerals, or carrying on boring operations for gas and oil, the public should investigate the statements made by the peddlers of stock certificates, enquire from reliable sources as to the possibilities of the enterprises, so as to be able to discriminate between (1) "safe mining investments," (2) "legitimate and reasonable mining speculation" and (3) "mining frauds." In the first the returns are not high but are reasonably sure; in the second, the money contributed by the buyers of shares is really expended in intelligent search and development on the mineral deposits, which may or may not answer the hopes which were founded on them; and the third class comprises the ventures of shady adventurers who spend the money obtained from the sale of shares, on full page advertisements, in printing alluring and tempting prospectuses for the purpose of obtaining more money, of which the smallest possible fraction is expended in actual work, usually on hopeless mining claims.

Shady and questionable promotions of mining companies have always been the bane of the industry. Mining entreprises, when reduced to a business basis, are quite as safe and as legitimate as any other commercial or industrial enterprise.

This subject is mentioned rather insistently owing to the fact that for some time past the Province of Quebec has suffered from an eruption of such promotions. Apparently operators of this stamp are searching new grounds for their activities and appear to have chosen the Province of Quebec as the latest scene of their exploits.

FIELD WORK

The Mines Branch of the Province of Quebec carries on as much special investigations in the field as possible, considering the limited appropriation and also the difficulty of securing the services of trained geologists and mining engineers for this purpose.

We have often drawn the attention of the public to the fact that a great deal of information on the mines, the mineral occurrences, the geology, the possibilities of the mineral resources, the mineral deposits of certain districts of the Province of Quebec can be obtained from the Reports published by the Quebec Mines Branch. Moreover, much information, which is contained in the records of this service has not been published, but is gladly given by correspondence to anyone interested when specific enquiries are made. Once more the public is urged to make greater use of the information from this source, and by so doing, much time and money may often be spared.

In January 1916 was distributed the Report on the Copper Deposits of the Eastern Townships, a volume of 291 pages and a map, giving the results of two seasons' field-work by Dr. J. A. Bancroft. The Report treats particularly of the copper deposits of the Sutton Belt, of the Ascot Belt and intervening region.

During the summer of 1916, Dr. Bancroft made an investigation of the mineral possibilities of the district traversed by the National Transcontinental Railway, between Hervey Junction and the Bell River. The report which is given further on, is not very encouraging as to the mining prospects of the region but, from the standpoint of utility and information, negative evidence is as important as positive evidence, and it is often very useful to the public to know that a certain district has been examined and found geologically unfavourable as to the occurrence of certain minerals.

The work of geological mapping is much hampered by the lack of good reliable topographical maps, on adequate scales, and as a rule the geological boundaries have to be plotted on separate township plans, which show only the lot and range lines, and a few of the main lakes and streams. Moreover the fitting together of these separate plans, which are the work of different land surveyors, into a homologous map is often a very trying work of patience and a source of time-loss.

Requests for examinations and reports of particular, privately owned, mineral deposits or mines, are frequently received by the Honourable the Minister or by the Mines Branch.

It should be understood that the Mines Branch can only undertake work which will benefit the province as a whole, such as regional investigations, examinations of districts, or the study of a certain ore over the whole province. In the course of such investigations the field-officer in charge will always do his utmost to advise and counsel the owners of mineral deposits in the district under examination, but it is out of the question to send out mining engineers from the official staff to make a report to a private individual on his private property, at the public's expense. For one thing, it would be a cause of serious complaint on the part of consulting mining engineers, for whom such work constitutes the main sources of income, and it would be a misapplication of public funds. The persons who make such requests should first consider whether the work asked for will be of public interest or will serve only private interests. There are of course cases which are on the border land, and which it might be excusable to confuse, but as a rule the work requested to be done is palpably to serve private ends.

PROVINCIAL LABORATORY

The Quebec Mines Branch maintains at the Polytechnic School, 228, St. Denis Street, Montreal, an up-to-date, well-equipped assay and chemical laboratory, for the convenience of the interested public. Analyses and assays, determination of mineral specimens and tests of various kinds of ores, samples and materials found within the boundaries of the Province of Quebec, are made in this laboratory at prices which are extremely low for the high-grade work done. The laboratory has been installed for the sole purpose of aiding the development of the mineral industry of the Province of

Quebec. Prospectors and all persons interested in the Quebec mineral resources are cordially invited to avail themselves of the facilities offered. The tariff in force for the analysis and assay of various substances is given further on, and it will be realized that the fees are very low, as the high competence of the chemists insure results of undoubted reliability.

During the year ending December 31st, 1916, the Provincial Laboratory effected 618 analyses and assays as follows:

Gold 116; silver 50; arsenic 2; carbon 8; lime 55; chrome 4; copper 36; tin 1; iron 35; magnesia 66; manganese 7; molybdenum 5; nickel 16; phosphorus 6; platinum 4; lead 6; silica 32; sulphur 13; titanium 7; zinc 5; radioactivity 1; incineration 19; water 1; density tests 2; fractional distillation 2; abrasion test 1; identifications of minerals 64; qualitative tests 54.

PROVINCE OF QUEBEC

GOVERNMENT ASSAY LABORATORY

(Under the direction of the Department of Mines of the Province of Quebec as an aid to the development of the mineral resources.)

TARIFF OF FEES FOR ASSAYS AND ANALYSES

DETERMINATIONS		Less than 5 samples Each:	For 5 samples or more Each:
		$ Cts.	$ Cts.
Moisture		0.25	0.25
Combined Water		0.50	0.50
Gold and Silver		1.00	0.90
Silica, Copper, Iron	1 constituent	1.00	0.90
	2 constituents in same sample	1.75	1.50
Iron, in titaniferous ore		2.00	1.80
Alumina, Cobalt, Graphite, Lead, Lime, Magnesia, Nickel, Sulphur	1 constituent	1.50	1.35
	2 constituents in same sample	2.50	2.25
Antimony, Arsenic, Bismuth, Chromium, Manganese, Molybdenum, Phosphorus, Platinum, Titanium, Zinc	1 constituent	2.00	1.80
	2 constituents in same sample	3.50	3.15
Commercial analysis of an iron ore, comprising determination of silica, iron, phosphorus, titanium and sulphur		6.50	5.85
Commercial analysis of a limestone or cement, comprising silica, lime, iron, alumina, magnesia, and sulphuric acid		6.00	5.40
Commercial analysis (proximate analysis) of a fuel, comprising: ash, volatile combustible, fixed carbon, moisture		3.00	2.70
Calorific power of a fuel		1.50	1.35
Radioactivity of a mineral		1.00	0.90
Radioactivity of a mineral water		2.00	1.80

Determination of Minerals.—For a nominal fee of 25c for each sample, the laboratory will make determinations of ores and minerals, provided rapid tests will allow it, and issue a report on probable contents and commercial value of specimens and samples.

Terms.—Money in payment of fees, by registered letter, postal notes or orders, must invariably accompany the samples, in order to insure prompt return of certificate.

Professor E. DULIEUX,
In charge of Laboratory
No. 228 St. Denis St., Montreal.

ASBESTOS

The shipments of asbestos during the year 1916 amounted to 133,339 tons valued at $5,182,905. In addition, 20,170 tons of asbestic, valued at $28,252, were utilized or shipped.

The rock mined and hoisted during 1916 amounted to 2,291,087 tons from which was extracted a value of $4,878,931 of asbestos. This is arrived at by taking into account the stock on hand at the end of 1916 and at the end of 1915. This represents an average value of $2.13 of asbestos extracted from each ton of rock mined. In 1915 and 1914 these tenors were $1.46 and $1.44 respectively.

The market could have absorbed a much greater quantity of asbestos but the output was limited and hampered by the shortage of labour. As the demand was greater than the supply, the prices rose accordingly, more especially for the higher grades. As a result, although the tonnage shipped in 1916 shows an advance of only 18% as compared with 1915, the value increased 46%.

The following tables give the detail of the production of asbestos for 1914, 1915 and 1916.

PRODUCTION OF ASBESTOS IN THE PROVINCE OF QUEBEC FOR 1916

Shipments and Sales			Average Value per ton	Stock on Hand Dec. 31st, 1916	
Designation of Grade	Tons	Value		Tons	Value
Crude No. 1	3,073	$1,299,138	$422.76	255	$100,931
Crude No. 2	2,885	634,041	219.77	201	28,596
Mill Stock No. 1	11,768	936,373	77.57	847	86,728
Mill Stock No. 2	43,870	1,248,740	28.46	1,500	55,971
Mill Stock No. 3	71,743	1,064,613	14.84	3,473	61,425
Total	133,339	5,182,905	38.87	6,276	333,651
Asbestic	20,710	28,252	1.36	228	334
Total	154,049	5,211,157	....	6,504	333,985

Quantity of rock mined 2,291,087 tons.

Production of Asbestos in the Province of Quebec for 1915

Grades	Shipments			Stock on Hand	
	Tons	Value	Average Value per ton	Tons	Value
Long Fibre, Crude No. 1	2,734	$750,112	$274.36	590	$176,523
Long Fibre, Crude No. 2	2,631	322,048	122.44	300	41,582
Mill Stock No. 1........	12,502	804,193	64.32	290	50,294
Mill Stock No. 2........	36,945	981,890	26.84	5,525	157,012
Mill Stock No. 3........	58,303	686,119	12.57	15,333	240,800
	113,115	3,544,362	31.33	22,038	666,211
Asbestic...............	25,000	21,819			
Totals...........	138,115	3,566,181			

Quantity of rock mined during the year 1915, 2,134,073 tons.

Production of Asbestos for 1914.

Designation of Grade	Shipments			Stock on hand Dec. 31st, 1914	
	Tons	Value	Average value per ton	Tons	Value
Crude No. 1............	1,336	$402,417	$301.96	985	$301,237
Crude No. 2............	2,812	370,776	131.85	1,345	187,688
Mill Stock No. 1........	10,485	633,289	60.40	2,737	166,761
Mill Stock No. 2........	32,847	818,765	24.93	9,757	231,874
Mill Stock No. 3........	59,921	670,688	11.18	16,968	204,429
Totals...........	107,401	$2,895,935	$ 26.96	31,792	$1,091,989
Asbestic...............	13,251	4,904			
	120,652	2,900,839			

Quantity of rock mined during year 1914:—2,127,395 tons.

The classification which is given above is arbitrary and is based on values of the different grades. In 1915 the values adopted for the division into classes were as follows:—Crude No. 1 comprised long fiber, hand-cobbed asbestos, valued at $200.00 and over a ton; Crude No. 2 under $200.00; Mill stock No. 1, $45.00 a ton and over; No. 2 between $45 and $20; No. 3 under $20. The same grades were retained in the same classes for 1916 at the increased market price.

The question of standardizing the classification of Asbestos, is a rather difficult problem to solve. So far, practically each producing company has its own grading, its own qualities and designations, and the marketing of asbestos has to be done almost altogether on samples submitted. The grading of the asbestos is based on (1) the "life of the fiber," which depends to a great extent on the strength of the threads; (2) the length of fiber, and (3) finally on the colour of the fiberized material. Of the total rock hoisted, a proportion of 20 to 25 per cent is barren and sent direct to the waste dumps. Thus 75 to 80% of the rock mined is treated in the mills for the extraction of asbestos.

Returns of production were received from eleven operators. Great activity reigned at Thetford Mines, at Black Lake and in the Danville district, but none of the Broughton mines produced this year. The demand was mainly for the higher grades of asbestos, and the Broughton mines producing only short fiber did not reap much benefit from the increased activity in the market.

The present quotations for Crude asbestos No. 1 run from $300 to $750 a ton. Some lots of selected material, for special purposes, may bring much higher prices and a few tons are said to have sold for $1,400 and $1,500 a ton.

The long fiber grades of asbestos are used for textiles, and they have found numerous applications in the war, such as gloves for handling quick firing guns, filtering material in the manufacture of gas masks. Asbestos of all grades is much used in ship building and in submarines, in machine rooms, both for heat insulation, boiler and pipe coverings, and as fire proof material.

An important quantity of asbestos cloth is now utilized in the manufacture of automobile tires, in which it replaces the heavy duck which was previously used altogether. It is claimed that the duck when laid over with hot liquid rubber is liable to be impaired and to deteriorate easily, whereas asbestos cloth remains quite unaffected.

A great deal of asbestos is used in the manufacture of electrical insulation materials and coverings, for both high and ordinary voltages, replacing rubber and cotton which deteriorating through age and weathering, leave the wires exposed. Asbestos is also used in the manufacture of insulating tape, which can be woven of fine enough texture to replace cotton.

The uses of asbestos for piston packing, gaskets, brakebands for motors and automobiles, and for the manufacture of building materials, shingles, sheathing, etc., are well known.

Some of the Canadian asbestos is shipped direct to England and France, but the great difficulty in this connection has been the lack of ship space. By far, the greater proportion is shipped to the United States and used in that country.

Soon after the beginning of the war, measures were taken by the Canadian Government to regulate the export of mining products, among which was asbestos. As the regulations now stand, it is prohibited to export asbestos, graphite, molybdenite, chromite, zinc and lead ores, manganese ore, to countries other than Great Britain and British possessions. However, special permission may be obtained from the Customs Department to export to other countries by going through the following formalities:—

To France, a permit has to be obtained from the Customs Department, at Ottawa, giving name of consignee, quantity, grade.

To Italy, same formalities, but sometimes shipments are directed to be addressed to the British Embassy or Consul, for delivery to ultimate consignee.

To Japan, all shipments have to go through British representatives there; the British Consulate controls the distribution.

To United States, the list of buyers of asbestos, who practically are all manufacturers, has to be approved by the Customs Department, at Ottawa. Each buyer in the United States has to send in a guarantee, in triplicate, that the asbestos shipped to them will be used in the United States, and will not be exported. One of these three copies is kept by Ottawa, the second is sent to the Customs officer at Thetford Mines, and the third to the seller. The buyers are manufacturers only, and if they wish to sell asbestos to a third party, they have to give a similar guarantee, which they may be called upon to produce under penalty of forfeiting permission to buy asbestos.

The Customs officer at Theftord Mines, has a complete list of approved buyers, and for each car of asbestos shipped, he delivers a permit which is attached to the way-bill for the Customs officer at the boundary. If a shipment of several cars be made at the same time to one consignee, one permit for each car, describing contents, has to be obtained.

In the report for 1915, full details were given regarding improvements and alterations in the various asbestos pits and mills. These have further been developed during 1916 and all the operating companies are constantly striving to attain as high a degree of efficiency as possible. This is of course necessary when the narrow working margin is considered. It speaks very highly for this efficiency, that the operators must make ends meet with rock whose tenor in asbestos amounts to an average value of $1.60 per ton as a mean for the last three years.

Towards the end of 1916, the East Broughton district was showing signs of activity. The Ling Asbestos Company, after a reorganization under the name of Quebec Asbestos Company, has undertaken extensive alterations in the mill which has been closed since 1912, and the Asbestos Corporation of Canada was doing some development work at the old Glasgow or Fraser Mine, on lot 14 range VII of Broughton, both companies with the intention of actively pushing mining and milling operations in the spring of 1917.

It may be mentioned that the B & A Asbestos Co. was reorganized under the name of the Federal Asbestos Co., in May 1916, and is now in full operation of the old B & A mine at Robertson, lot 9, range V, of Thetford township.

The Asbestos and Asbestic Company went into liquidation and was reorganized under the name of Manville Asbestos Company.

The Robertson Asbestos Company has changed its name to the Regent Asbestos Company, but the mine was not operated in 1916.

The Windsor Asbestos Co., who owns mining rights in the township of Coleraine, has erected a mill on lot 4 range IV of the township of Coleraine, and has begun the installation of the machinery. Moreover, this company constructed a railway spur, three miles long connecting the mill with the Quebec Central Railway, at Coleraine Station.

It is interesting to note that the Martin-Bennett Asbestos Company did some prospecting work on the King Bros.' property, on lot 26, range III of Ireland township, from which 30 tons of crude asbestos was procured. The results were very satisfactory and development is being actively pushed.

ASBESTOS IN OTHER COUNTRIES

UNION OF SOUTH AFRICA.—According to the returns made to the Department of Mines of the Union, the production of Asbestos of South Africa in 1915, totalled 2,138 tons valued at £35,899. On the other hand the export figures from that country show that 3,034 tons were shipped during that year. It is probable that the difference can be ascribed to shipments from stocks. As the exports for the previous year had been 1,276 tons, it can be realized that the industry has notably progressed.

For many purposes, the Cape asbestos can never be a competitor of Quebec asbestos, but on the other hand both can be put to many common uses.

The Quebec or Canadian asbestos is the chrysotile or fibrous form of serpentine, very silky, perfectly white when fiberized, and very refractory to heat. It can stand temperatures of 3,000 degrees F. without alteration, and some samples have successfully withstood tests of 5,000 degrees.

It can be fiberized into very tenuous, silky threads, and when they are sufficiently long, they are admirably adopted to the weaving of incombustible fabrics. In composition, it is essentially a hydro-silicate of magnesia, containing in average:—silica 40%, magnesia 42%, water 14%, the balance being alumina and iron oxides.

The South African asbestos is of amphibole variety. It is called crocidolite and is essentially an iron-sodium silicate. Dana gives its composition as:—silica 49.6%; iron sesquioxide 22%; iron-protoxide 19%; and soda 8.6%. It is of a dark bluish lavender colour when unaltered, but is frequently rusty and discoloured. It does not stand very high temperatures without being affected, probably owing to high contents of iron. On the other hand, the fibres are very strong, contrary to other asbestiform varieties of amphibole.

In the Annual Report of the Department of Mines of the Union of South Africa for 1915, Mr. G. E. B. Frood, Deputy-Inspector of Mines, furnishes some very interesting notes regarding the asbestos industry of the Cape provinces. As the subject is of great importance to the Quebec asbestos industry, no apology is needed in reproducing, almost in its entirety, Mr. Frood's technical contribution to the report of the South African Department of Mines.

Memorandum on the Asbestos Industry in the Cape Provinces
By G. E. B. Frood, Deputy-Inspector of Mines

Blue asbestos is found in the lower Griquatown beds, and this series, for present purposes, may be taken as identical with the range of hills known as the Asbestos Mountains and the continuation north of these in the Kuruman-Honingvlei range. Mineralogically, the mineral is asbestiform crocidolite.

This mineral is said to have been discovered thirty miles south of Prieska, and it has certainly been opened up as far north as the border of the Bechuanaland Protectorate. Taking the rather sinuous course of the above hills into account, this would indicate a lineal extension of well over 300 miles. Throughout that distance, the asbestos deposits are found to occur in greater or less abundance. There may be small stretches in which it has not yet been opened up or in which it has not afforded satisfactory prospects of payability, but, so far as is known, there is no portion of these hills on this line in which it can be said positively that it will not be found.

Looking to the extension that has been indicated above, we have in the three Districts of Kuruman, Hay and Prieska, much the largest asbestos-bearing area in the world. Even if we were to allow for considerable failure in continuity from north to south or across the series, the fact would still remain.

Principal Occurrences.—The richest occurrences so far opened up to any considerable extent are those at Koegas, right on the Orange River. From Koegas to the Bechuanaland border, 130 miles to the north-east, we have only occasional properties working, but, according to the testimony of Dr. Rogers, there is scarcely a farm on this line throughout the Hay District on which asbestiform crocidolite, or one of the series of products of oxidation and silicification derived from it, is not known to exist. From the Bechuanaland boundary on to Kuruman we have a practical succession of asbestos properties, and even from the latter on to Tsenin there is very little ground which it has not been thought worth while to take up either on lease or prospecting title. It remains to be pointed out that whilst work has been proceeding quietly at Koegas for twenty years or more, the development of the Kuruman field is a mere matter of yesterday.

Prospecting.—All the prospecting that has been done so far has been simply of the nature of examination of the exposed strata appearing on the hillsides. As the formation is very nearly horizontal, the same strata will often appear on successive hills, and thus one discovery will lead to another. So far as I have heard, it is only at Khosis that the mineral has been found elsewhere than in the hills, and there, as I understand, only to a small extent. When one considers the limitation of this matter of prospecting in conjunction with the enormous area of the known asbestos-bearing formation, it will be recognized how great are the possibilities for future discoveries, and that the mere fringe of the deposits has yet been investigated.

Mining Methods.—The only mines on which we have considerable reserves actually developed and in sight are those of the Cape Asbestos Company at Koegas and Westerberg. Those are mines developed underground on normal lines, as also are the workings at Naauwpoort and Elandsfontein in the Hay District. At Wonderwerk, in the Kuruman District, a good start has been made with tunnelling and stoping underground, and the system has approved itself. At Bretby, in the same district, some work has also been done on similar lines, though only, so far, in a rather tentative and experimental way. These are the only properties known to the writer on which any underground work worth speaking of has been done, but there may be others, and at any rate quite enough has been done to show both that the seams maintain their value underground and that they may be profitably worked.

Elsewhere the recovery is obtained from surface quarrying, but undoubtedly the seams that have been discovered and worked at surface to more or less profit on a larger number of properties indicate supplies that will generally prove to be available for profitable extraction by underground methods later.

The Cape Asbestos Company Limited.—The history of the asbestos industry in the Cape has been, until quite recently, practically that of the Cape Asbestos Company, and that corporation still controls the great bulk of the production, though a larger proportion of the output appears to be gradually reaching the market from independent sources.

The above company was formed as far back as 1893, and since then has put the Cape industry generally under an irredeemable obligation by the fight it has maintained to gain for blue asbestos the due recognition to which it is entitled in face of formidable opposition.

The position ultimately forced upon the company by the opposition—which came from the chrysotile or white asbestos people—was that it was obliged to mill and manufacture its products itself.

This it accordingly set itself to do, and as the result of this policy the company has now its own factories not only in England but also at Turin and Hamburg. The most important development, however, has been the formation of a sister company in Paris—the Compagnie Française de l'Amiante du Cap—to take over the goodwill and trading right in France with certain options as to shares and as to the supply of raw material on fixed terms.

At the present time the company, in addition to handling perhaps two-thirds of the whole local production—partly the output from its own mines and partly from contractors working outside properties—is also much the largest European manufacturer of blue asbestos goods.

Labour Conditions.—As the industry has been fortunate in its pioneers, so also has it been in what is undoubtedly the most important factor to successful production, that is to say, the labour available. There is no industry in South Africa so entirely in the hands of, and dependent upon, the native labourer. Actually, practically all the mining and extraction work is done by natives, working on contract or being paid by results. Development work is generally paid for independently, but, apart from this, payment is made by the sack of cleaned asbestos fibre, the price varying further according to the length of the fibre as sorted and bagged.

The most important feature of the mining conditions is that the asbestos seams are followed in shales, which, though varying somewhat from point to point, are generally hard, tenacious, and, in a degree, elastic. Generally the strata are practically horizontal, though at Koegas and Westerburg the beds have been tilted to nearly vertical. In either case, the conditions, from the point of view of safety, are nearly ideal. The shale breaks into slabs of regular thickness which are perfectly adapted for packing, and, consequently, where the strata are horizontal, the placing of packs becomes not merely an end to safety, but, at the same time, the cheapest and easiest way of disposing of the waste rock. Where, on the other hand, the strata lie vertically, there does not appear to be any greater difficulty in sorting out the fibre underground, leaving more than sufficient waste there for packing underfoot as stoping overhand proceeds. A good deal depends on choosing the stratum that will give the best roof or side, as the case may be, whilst not unduly increasing the width of the stope, but, so far as one could see, the native miner seemed sufficiently alive to such considerations of safety, as well as to finding the cheapest methods of extraction.

The cheapness of working is remarkable. On two properties single veins of asbestos not averaging more than one inch in width were being mined hundreds of feet in from the outcrop and the product being finally put on the market at a profit. A common figure for total labour charges for stope-driving or development-driving was 7s. a foot, but in one place it was being done as low as 5s.

Recovery Problems.—Where underground methods are to be followed, the configuration of the ground naturally calls for the opening up of the deposits by adits. The advantages of this method of development are so considerable that it would probably be best in the interest of the industry that all properties were worked on an underground system from the start.

In following a seam or seams in practically horizontal strata in a fairly steep hillside, it can be well understood that the first few feet pay very well, little ground having to be broken for the asbestos recovered. Very soon, however, one is put against a high face, the removal of which involves expenses disproportionate to the asbestos values, and work in the open has to stop. If instead of now following the seams underground, one simply moves on from one place to another, pig-rooting the surface, so to speak, it can be understood what mess is finally made. It is really doubtful whether such methods pay in the end, but so long as the immediate realization of values is the only object, so long will this system of recovery be continued.

At Koegas and Westerberg, in the south, one had seen such a concentration of values in a certain zone that there was no question as to what was before one. We there find an average of perhaps four or five seams of asbestos, from ¼-inch stuff upwards, within a zone of 12 to 18 inches, though in places, and in some instances for considerable distances, especially at Westerberg, the number increases to eight, nine, or ten seams within the same or a little greater width. At the same time, so far as I know, there is nowhere else in the hill-side that any zone of approaching this richness will be found. On some of the Kuruman properties, such as Bretby, on the contrary, the asbestos may be worth following in a succession of terraces at irregular intervals right from the bottom to the top of a hill. The difficulty there becomes, accordingly, to pick the most profitable zone or zones on which to concentrate work. Further, exceptional places occur, some carrying as many as from twelve to seventeen veins in a face of not over 6 feet, whilst 20 feet away we are down to one or two, so that a good deal of averaging out is necessary before the best paying zones can be decided upon. One may have been carried away in the meantime by contemplation of the total asbestos in sight, but a more rational view is restored when we come to realize the fact that the question of payability depends upon the number of seams one can bring within the stope face and the length of fibre carried by the respective seams.

Irregularity of Deposits.—Whilst the mining conditions as already described are very simple, the distribution of the asbestos, both as regards the number of seams found from point to point and the length of the fibre, is very irregular.

Preparation of Fibre.—At Koegas there is some plant and machinery, but all that is attempted is a rough cleaning of the short and inferior fibre. The milling plant, as a matter of fact, consists only of a pair of corrugated rolls arranged to run at different speeds, and of some sieving trommels. Beyond sieving the same particular grade in some cases, no preparation of the material is attempted on any of the other properties.

Classification of Fibre.—The classification of fibre is on an entirely different footing, and much care and attention is given to this matter. This can be well understood, when one considers that much of the material must be bought by sample or at sight on the European market. In actual work, higher contract prices are paid for the longer fibre, and, accordingly, care has to be taken that the natives do not succeed in getting inferior qualities mixed in. The same care may have to be exercised in buying from outside contractors and sellers.

The classification, as far as done locally, is very simple, but no doubt, as in the case of white asbestos, a much more elaborate sorting will generally be necessary in the end. Common standards of local classification are (1) from ⅜ inch to ¾ inch; from ¾ inch to 1¼ inch; 1¼ inch to 2 inch; and 2 inch and over; and (2) ¼ inch to ½ inch; ½ inch to 1 inch, etc.

The product according to its class, is put up in bags and marked. These bags, which are generally filled so as to contain 100 lb. of cleaned fibre or a little over, are checked, tallied, and gathered at intervals on behalf of the owners and finally weighed and dispatched to rail.

Length of Fibre.—It is understood that, for textile purposes, about 25 per cent of the fibre must be 1 inch and over. In these conditions, it is of interest to know that the average length of fibre as mined in Kuruman District is somewhat over the standard. That from the south is understood to be lower, but probably the average for the whole field of the present production will not fall very greatly short of the high standard mentioned.

Proportionate Price.—The best blue asbestos has realized recently £45 a ton on the European market, whilst some special parcels have gone as high as £65. Other current prices are from £16 to £18 for ¼-inch to ½-inch stuff, £25 to £27 for ½-inch to 1-inch, and £30 to £35 for 1-inch and over.

Average Price Realized.—Making allowances for discoloured fibre (which will be referred to later), the whole Cape output realizes at present an average of about £25 a ton landed in England.

Rusty and Discoloured Material.—One sees a great deal of rusty fibre in the Kuruman District. It is generally yellow or reddish, obviously the result of decomposition of the blue material, and could scarcely be taken as likely to be of any practical use or value.

Discoloured material is in quite a different position, and at the present time the questions that arise regarding it give cause to much soreness amongst the producers in the north. It is a matter that apparently requires some technical knowledge to appreciate, but from what I can understand it would appear that, whilst a lot of this class of material is plainly enough of inferior quality, the great bulk is not apparently so. The colour may be slightly off, but it is not easy for a non-technical person to appreciate any other physical difference. The home buyers appear to arrogate to themselves the right to reject material more or less wholesale on this ground of colour, and the producers have no way of redress when they consider themselves unfairly treated.

Comparison with Chrysotile Asbestos.—To appreciate the main differences between blue asbestos (crocidolite) and chrysotile or white asbestos, it becomes necessary to refer to the comparative analyses, of which the following may be taken as typical:—

		No. 1	No. 2
1. Crocidolite... (Blue Asbestos).			
	Silica	51.1	51.22
	Protoxide of Iron	35.8	34.08
	Soda	6.9	7.07
	Magnesia	2.3	2.48
	Oxide of Manganese	....	.10
	Lime	....	.03
	Water	3.9	4.50

		Canadian	
2. Chrysotile... (White Asbestos).		Thetford	Black Lake
	Silica	39.05	39.36
	Magnesia	40.07	42.15
	Iron (FeO, FeO_3)	2.41	3.31
	Alumina	3.67	.....
	Water	14.48	14.50

To the presence of such a large proprotion of iron and comparatively low content of water must be attributed whatever virtues, as well as whatever failings, that variety of asbestos may discover as against its rival chrysotile.

No estimate of the comparative values of these two varieties, even as regards the attributes or qualities in which they come into direct competition, can be well offered as entirely reliable, in view of the violent differences of opinion expressed on the subject. Blue asbestos, in particular, is still struggling against the initial prejudice with which its more recent entry into the market was received. In some markets strangely enough—in South Africa for one—it is still almost unknown, and its merits have not generally obtained the recognition to which they are properly entitled.

Of the greater heat-resisting qualities of chrysotile there does not appear to be much question. In case of some varieties it has been known to withstand a temperature of 5,000°F. without being appreciably affected. So, also, there can be no doubt of its superior softness, making its milling and reduction so much easier and at the same time fitting it specially for such purposes as gland packings, already alluded to. On the other hand, blue asbestos can undoubtedly lay claim to certain intrinsic virtues peculiarly its own. The fibre, in addition to being lighter, is stated to be longer, stronger, finer, and more elastic. Its superior efficiency as an insulating material as regards heat appears to be well established, and a similar superiority is also claimed for electrical insulation purposes. It is said to be unaffected by moisture, ordinary acids, or chemical solutions, and, in particular, to be unaffected by sea-water. It must also be kept in view that, even if inferior to its rival in heat-resisting qualities, still its efficiency in this respect is sufficient for most industrial purposes. (*Extracts from Annual Report of Department of Mines of the Union of South Africa for 1915.*)

RHODESIA.—The asbestos deposits of Rhodesia are being developed steadily and they are taking importance. The production in 1914 had amounted to 487 tons, valued at £8,612, whereas[1] in 1915 this increased to 2,010 tons valued at £32,190. During the first three months of 1916 the production was 914 tons valued at £14,621.

This field is situated in Victoria township in the Mashatee district, Southern Rhodesia. The asbestos, unlike the Cape mineral, is a chrysotile of excellent quality.

UNITED STATES.—The restrictions put on the export of Canadian asbestos and the keen demand for this substance during the whole of the year 1916, caused a great activity in the development of the known occurrences in the United States. The principal

[1]Report Rhodesia Chamber of Mines, Bulawayo.

field now known is in Arizona in the Ash Creek district, where the "Arizona Asbestos Association" has a producing mine.

According to J. S. Diller, in "The Mineral Resources of the United States for 1914," the asbestos of Arizona is not only of excellent quality but is unique in mode of occurrence. "It is chrysotile and occurs in cross-fibre veins, with serpentine, in limestone. ....It outcrops in steep-walled stream canyons, in which it is not easily accessible....."

"The asbestos is regularly mined by tunnels run into the walls of the canyon, a method of mining that contrasts strongly with the open-quarry method of mining the chrysotile in Canada. The application of regular mining methods to win the Arizona asbestos is necessitated by its mode of occurrence and the large proportion of high-grade material. The underground workings, of which perhaps 1,000 feet have been run, average about 90 lbs. of No. 1 fibre per foot of tunnel driven. It should be noted that the mode of occurrence and the mining methods necessarily limit the output, so that the yield of asbestos must always remain relatively small, although its high grade assures its value. It is more than probable that chrysotile will be found at other points in the Arizona field and ultimately form the basis of an industry."

In 1915, according to the same authority, the asbestos industry of Arizona developed steadily.

The Arizona Asbestos Association was the only producer, and although only the crude, or long fibre asbestos, is shipped at present, a large tonnage of milling rock of shorter fibre has been accumulated. A small experimental mill has been erected and a road completed to the mine, where more than 4,000 feet of tunnels have been developed within canyon walls. It is said that in 1915 the shipments were a ton a day. The asbestos has to be packed on burros, from the mine to Globe or Rice, 35 miles, on the Arizona Eastern Railroad.

Mr. P. E. Joseph, in a bulletin published by the Bureau of Mines of Arizona, gives the following data, regarding the occurrence of asbestos in the Globe district:

Asbestos in Globe District.

"The first discovery of asbestos in the Globe district was made by T. D. West in 1913, on Ash Creek. Fourteen claims were taken up by T. D. West and F. Patee on Ash Creek, about 25 miles in a direct N. 25° E. line from Globe. Ash Creek is a short stream, heading against Sycamore Creek and flowing north through a rugged canyon into Salt River. The asbestos occurs at a depth of 600 feet in the canyon, the eastern slope of which has the following geological section:—

	Thickness
Diabase	175 feet
Layers of gray-white limestone, carrying 3 belts of asbestos 12 to 24 inches in thickness	30 feet
Gray limestone, partly cherty, locally banded and containing sheets and nodules of serpentine and some asbestos	150 feet
Quartzite and some conglomerate	300 feet

Nodules of serpentine occur here and there in the locally banded limestone near the asbestos belts. The asbestos belts, especially the one near the contact with the diabase, are more or less continuous for a mile, but vary from place to place.

The principal belt is the one nearest the diabase and is usually separated from the diabase by a few feet of limestone. Other belts occur higher up in the limestone to a distance of about 30 feet. The limestone is cut by a dike of diabase rising from the main body; the highest grades of asbestos are found in the limestone where it is cut by the diabase dike.

Since the first discovery of asbestos in the Globe district by West, a number of other claims have been located, all in the vicinity of Globe, and very active development work is carried on throughout the district. A notable event in the asbestos industry of the state has been the recent installation of a milling plant at the Fisk and Snell property on Ash Creek, 40 miles from Globe. The mill was constructed by E. Torrey, who was brought here from the Canadian asbestos field for the purpose, and embodies many new principles that are the outgrowth of the inventor's many years experience in asbestos mining and milling.

In occurrence, origin, quality and quantity, the asbestos deposits of the Globe district are the same as those of Grand Canyon district, but the former are much more accessible, being at a depth in the canyon of not more than 800 feet and within 30 to 40 miles by trail and wagon road from the railway."

COPPER AND SULPHUR ORES

The keen demand for copper and the high prices which ruled during 1916, particularly towards the latter part of the year, stimulated copper mining activities in the province of Quebec. Unfortunately one of the important producers, the Eustis Mining Company worked against odds, as their concentrating mill was burnt down in the fall of 1915, and although the erection of a new one was started immediately without delay, it could not be put in operation before the early part of the summer of 1916. This fact militated against a high tonnage of shipments, which reached 131,017 short tons, as compared with 142,797 tons in 1915. The value, however, owing to the increased price of copper and sulphur, was $1,259,064, as compared with $1,021,777 the previous year.

The ore shipped contained 8,187,386 lbs. of copper, according to returns received.

The two most important copper ore producers of the province of Quebec, are the Weedon Mining Company, operating the "Macdonald Mine" at Weedon, on lot 22, range II of the township of Weedon, and the Eustis Mining Company, operating the Eustis mine at Eustis, near Capelton, lots 2 and 3 range IX of Ascot township.

At the Weedon mine, the workings have reached a depth of over 700 feet on an average inclination of 40°. The deposit which is being worked here has been fully described in the Report on the copper deposits of the Eastern Townships, by J. A. Bancroft, as well as that worked[1] by the Eustis Mining Company, which has now reached a depth of 4,000 feet, on an average slope of 38°.

The new concentrating mill of the Eustis Mining Company, to replace the one which burnt down in the fall of 1915, was put in operation in the latter part of the spring of 1916. It has a mill feed capacity of 12,000 tons of ore a month. The main concentration is done by eight large Wilfley tables, but an oil flotation process is being installed to further treat the tailings from the tables.

Several carloads of pyrite were shipped from the workings situated on lot 8 range VI S.W. of Stratford township. In 1915, at this prospect had been installed a surface plant, consisting of

[1] Published by Department Colonization, Mines and Fisheries, Que.

head frame, shaft house, compressors, hoists and an inclined railway which lowered the ore to a bin, from which it was teamed to St. Gérard station, a distance of seven miles. In the first part of August this plant was burned down and work has not been resumed since.

Mr. Pierre Tétreault, of Montreal, continued development work on the Huntingdon mine, at Eastman, and shipped some good ore. Most of this work has been done on the surface, and consists of two shallow shafts of about 50 feet and trenching. This property was purchased in 1913 from the Nichols Copper Company who had worked it until 1893. A description of the mine is given in the report on the Copper Deposits of the Eastern Townships, quoted above.

A considerable amount of work was done on a copper prospect situated on lot 42, range IV of Dalquier township, in Abitibi district discovered in 1913 by Jos. Tremblay, of Amos. The Campbell and Forbes Syndicate developed it under option during the summer of 1916, and made a test shipment of 20 tons of ore containing 6% copper.

The deposit consists of a mineralized sheared zone, in a schistose, foliated quartz porphyry. The ore is found in stringers of chalcopyrite with quartz as gangue. Most of these stringers are parallel to the schistosity, although a large number cut the foliation obliquely, showing that the mineralization took place subsequently to the schistosity. The general direction of the schists is 126° magnetically, and they have a dip of about 85° to the North. The sheared mineralized zone has been uncovered, by trenching at intervals, over a distance of 800 feet. A shaft was sunk, 54 feet deep, and a cross-cut driven towards the North, for a distance of 44 feet. In the cross-cut several stringers of ore are visible.

Some work was done on a copper prospect on lot 5, range I of the township of Newport, county of Gaspé, by Mr. W. A. Lenthall and associates. The rock is a fine grained greenstone, (volcanic tuff) cut in all directions by quartz and calcite veins of all sizes, up to six inches. The copper-mineral is chalcocite, in splotches in the veins, as well as in the greenstone in the immediate vicinity of the veins. The tenors are not high. Some Boston interests, "Gaspé Syndicate, 511 Shawmutt Building, Boston," have secured an option on the property and intend to thoroughly test the property by diamond drill holes.

Some considerable prospecting work, including a shaft of some 50 feet deep, was done on lots 22a and 22b, range V, of Stoke township by the Arizona Canadian Copper Syndicate. Apparently the results were not satisfactory, as work was abandoned at the beginning of the winter.

Prospecting work was carried on in Saint Denis township, county Matane, on lots 1 and 2, range IV. The main excavation 16 feet by 6 feet, 13 feet deep, is entirely in a greenstone which weathers to a pinkish grey on the surface. On the walls of the pit several veinlets of crystalline calcite are visible, some of which are 1½ inches wide. In these veins occurs native copper, usually associated with quartz. The work, which was done for Mr. Pierre Tétrault, of Montreal, was carried on for a little over a month and was stopped early in October.

CHROMITE

The total tonnage of chromite produced in 1916 was 27,952 tons, valued at $312,901. In 1915 the shipments were 14,397 tons valued at $245,297. The figures of tonnages, however are not comparable, for last year only the shipping ore left the mine, as there were no concentrating mill in operation. In 1916, a considerable quantity of low-grade ore, and even of tailings from an old concentrating mill on the shore of Black Lake, was sent to the concentrator of the Mutual Chemical Company, a custom mill which started operations in the spring of 1916. Thus of the 27,952 tons, only 15,412 short tons were actually marketed, the difference representing the tailing of the concentrator.

The figures of production constitute a new high record. The industry was very active and the ruling prices in the fall of 1916 were considerably in advance of the prices in 1915.

The prices quoted in November, 1916, for chromite, f.o.b. at Quebec Central stations were as follows: 25% of sexquioxide of chrome, $18.00 a long ton; 30% ore $22.50; 35% ore $27.50; 40% ore $33.00; 45% ore $38.75; 50% ore $45.00. Some special lots, assaying over 50% were sold at the rate of one dollar a unit.

When it is remembered that before the war chromite was quoted $14.50 in New York for 50% ore, the revival of the Coleraine chromite industry is not to be wondered at.

The Dominion Mines and Quarries is operating the Montreal Pit, lots 25 and 26 range II of Coleraine, from which low-grade chromite is being shipped. The ore is mined under contract given out by the company to Mr. Aurèle Paré.

The same company is also working their other property on lot 16 range A, Coleraine.

The Black Lake Asbestos and Chrome Company, which were the largest producers in 1916, mined on lots 27 and 28, range B, of Coleraine. The ore sufficiently rich was shipped direct to consumers, but the larger proportion was sold to the Mutual Chemical Company of Canada and was concentrated at the Black Lake mill.

Mr. J. M. Johnston mined a considerable amount of chromite on lot 26, range B, Coleraine, known as the Ross mine. All was shipped direct to the United States, being sufficiently rich to be used without concentrating.

The Bennett and Martin Chrome Mines have worked several prospects on the property of the King Bros., comprising lots 23 to 28, ranges I, II and III of Ireland township, north of Coleraine station. The main workings are on lots 26 and 27 range II; lot 26 range III, and lot 28 range I. Very satisfactory results were obtained and a considerable quantity of both high-grade chromite and crude asbestos were mined and shipped. The main workings are on lot 28, range I, where from an opening 300 feet long, and 10 feet wide, several lenses of chromite were mined. A very compact plant has been installed consisting in the main, of two compressors, driven by two fuel oil engines of 23 H.P. each; one gasoline-driven compressor of 10 H.P.; three hoists of 8 H.P. The ore is teamed to the station of Coleraine, the distances from the two main workings being about two miles and four miles respectively.

J. V. Bélanger of Black Lake worked on lot 19, range X, of Coleraine, where he had thirty men employed for nearly six months. Most of his ore was sent to the mill of the Mutual Chemical Company of Canada for concentration.

An appreciable quantity of chromite was mined on lot 23, range III, Wolfestown, by Messrs. J. D. Kennedy and Jos. Roberge.

Mr. D. Wilson worked the property of the American Chrome Company, under lease, and shipped some chromite from lots 6 and 7, range B, Coleraine.

Mr. W. J. Woolsey worked the Standard mine at Black Lake for chromite during practically the whole year, and shipped an appreciable quantity of ore.

Some prospecting for chromite was done on lots 7 and 8, range X, township of Cleveland, by Mr. Douglas B. Sterrett and associates. Prospecting started in November, mining began in December, and on January 5th, 1917, a first shipment of chromite was effected.

The Mutual Chemical Company of Canada, under the management of Mr. John A. Baker, reopened the mine of the old American Chrome Company, lots 6 and 7, range B, of Coleraine. A large modern concentrator has been installed. The building is 62 feet by 100, and contains Blake crusher (10″ x 20″); chain elevator; Hardinge mill (6′ x 22″) with chrome steel balls; a standard duplex Dorr Classifier; a Dorr Thickener; Callow screen; and seven Wilfley tables. The concentrates are dried by steam heat. Three electric motors, of 60 H.P. for the Hardinge mill, 30 H.P. for crusher and the elevator machinery, and 15 H.P. for the rest of the machinery, respectively, run the mill. The installation is intended to concentrate 80 tons a day of 12 to 15% ore to 15 or 16 tons of 50% ore. The concentrates are to be teamed 4½ miles to the railway.

A trial run in December gave satisfactory results. The principal mine workings are on lot 6. All the mining is done in open pits. On lot 7, a great deal of trenching has uncovered a wide band of serpentine containing irregularly disseminated chromite. The company has another mill at Black Lake near the track of the Quebec Central Railway. This is the old mill of the Black Lake Chrome and Asbestos Company, which has been repaired and is now used as a custom mill. The machinery consists of jaw crusher, six batteries of five stamps each, and seven Wilfleys tables. The concentrates, which are 50% Cr_2O_3 or more, are all shipped to the Mutual Chemical Company of America. The feed capacity of the mill is 70 tons of 15% of ore.

In August, 1915, the Fletcher Pulp and Paper Co. of Sherbrooke, began work on a chromite prospect situated on lot 4, range XII, township of Orford (given by error as range X in last year's report), and by the end of that year a few shipments had been made. In 1916 work was actively continued and several hundred tons of chromite shipped. The main workings consist of an open pit which reached a depth of over 75 feet. The chromite occurs in lenses in a serpentine. The deposit is situated on top of a hill, one mile north of Lake Webster. The ore is conveyed on sleds to the shore of the lake, where it is loaded on wagons. These are ferried across the lake to the road over which teaming is done to Sherbrooke, a distance of thirteen miles.

The exportation of chromite is subjected to the same formalities as asbestos. Consignments can only be made to buyers approved by the Customs Department at Ottawa, and each car has to have a permit delivered by the Custom Officer at Thetford Mines. The permit is attached to the waybill, for the Custom Officer at the boundary.

The demand for the Canadian chrome is very brisk, due, of course, to the great difficulty in getting sea transportation for New Caledonia and Rhodesia ores. The main uses of chromite are: for the manufacture of ferro-chrome; in the manufacture of chromates; in the manufacture of pigments; and lastly, as refractory material for the linings of metallurgical furnaces.

Ferro-chrome is an alloy of iron and chromium, composed of 60 to 65% chromium; 22 to 35% iron; 0.25 to 10% carbon; 0.2 to 5% silicon. It is extensively used in the manufacture of special steels which require hardness and toughness, such as for armour plates, projectiles, steels for safes, wearing parts for rock crushing machinery, and particularly for high speed tool steels.

According to Mr. R. M. Keeney[1], ferro-chrome is now made almost exclusively in electric furnaces. It is made in several grades according to carbon contents. For general castings and armour plates a high carbon ferro-chrome may be used, which is made cheaper than carbon-free ferro-chrome. The production of the alloy free from carbon or of very low carbon tenor (0.3 to 0.7) requires a refining, which process seems to add from $200 to $300 a ton to the cost of the product. For the manufacture of tool steels and high speed steels, ferro-chrome must be low in carbon.

Chromates are much used in the tanning and in the dyeing industries. Chrome leather resists moisture and is very tough.

It is probable that 60 to 75% of the production of chromite is used as refractory material for the lining of metallurgical furnaces.

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[1] U.S. Bureau of Mines, Bulletin 77, "The Electric Furnace in Metallurgical Work."

Much of it is manufactured into bricks. Chrome brick and coatings constitute a neutral refractory lining which stands both acid and basic charges. Although chromic oxide is not fusible at metallurgical temperatures, chrome brick do not stand very high heat without fusing on account of the impurities which they contain, the actual contents of Cr_2O_3 being only about 40%.

The two main sources of the world's supply of chromite are the deposits of New Caledonia and those of Rhodesia. The following notes on the Rhodesian deposits of chromite are interesting:[1]

"There are two distinct sources of chromite in Rhodesia. The most important is that exploited at Selukwe. This occurs in the Talc Schists and is largely in the form of "pockets" or lenses, which commonly reach considerable size and form clusters. This group of deposits has been described in detail by the Geological Survey. Another occurrence of this type is known in the Victoria district, in the neighbourhood of the asbestos quarries. It promises to be important, but is not yet worked. It is likely, too, that the Talc Schists in other parts of Rhodesia may be found to carry bodies of chromite.

"The second source of chromite is the Great Dyke, which occupies a narrow strip of country stretching from Belingwe through Selukwe, Rhodesdale and Makwiro to Unvukwe. The patches of peridotite and serpentine in the Great Dyke contain thin patches of chrome-iron ore, which may become economically important.

"The abundance of high-grade ore available makes it unnecessary to mill and concentrate the poorer ore, as is done in Canada and the United States. But when the high-grade deposits become exhausted, it may be found profitable to treat the still more abundant low-grade ore and even the alluvium in places."

ZINC AND LEAD

Concentrates of zinc and lead were produced by the Zinc Company, Limited, operating a part of the Tétrault mine at Notre Dame des Anges, in Montauban township.

The zinc concentrates shipped amounted to 2,754 tons, of 40% zinc and 647 tons of lead concentrates at 60%, having a total value of $140,850.

[1] Report of Rhodesia Munitions and Resources Committee, Bulawayo, 1st June, 1916.

The main shaft of the Zinc Company, Limited, is practically on the line between lots 39 and 40, range I, of Montauban. The workings have reached a depth of 250 feet on the dip, of 58°, and a great deal of development work is carried on. The property was described in detail in Dr. J. A. Bancroft's report on the region, published in the report of the Mining Operations in the Province of Quebec during the year 1915. Since then, a very complete mill has been erected near the mine. Mr. Tétrault has again taken possession of his concentrating mill, which had been used by the Zinc Company for experimenting and evolving a process of separation and concentration.

The new mill consists, in the main, of a jaw crusher, ball mill, classifiers, tables and a mineral separation flotation machine. The power used is supplied by the Shawinigan Water and Power Co., from their St. Casimir sub-station. The power is supplied at the rate of $48 per h.p. year, during the two first years, and $28 for the subsequent years. The mill has a feed capacity of 200 tons a day.

Mr. Pierre Tétrault, on the adjoining lot, No. 40, made some preparations to resume work, but did not ship any ore or concentrates during the year. The concentration mill, which was used by the Zinc Company for experimentation, was being remodelled towards the end of the year, to use electric power instead of steam.

The Montauban Mining Syndicate, operating on lot 43, range I S.W. of Montauban township has not yet shipped any ore. The underground workings amount to over 400 lineal feet of shafts crosscuts, winze and drifts. In October, work was begun on the erection of a concentrating mill, which appears to be somewhat previous, judging by results of the prospecting and development work done so far. In February, 1917, the building was practically completed, but no machinery had yet been installed.

The deposit is well described in Dr. Bancroft's report[1] published in our last annual report.

The Oka Gold and Lead Mining Company, Limited, has taken an option on the mining license held on lots 162, 163, 164, of Côte St. Isidore Sud, at Oka, and has started to unwater a prospect shaft sunk several years ago, and to put up buildings, blacksmith shops, boarding house, boiler and compressor house.

The mining claim on which the shaft is sunk was staked out in 1910, and since then assessment work has yearly been done, result-

[1] See Mining Operations in Province of Quebec during 1915.

ing in a shaft 45 feet deep, at the bottom of which a drift 12 feet long was driven. The dump accumulated near the shaft does not show much mineralization in the rock.

The Oka Gold and Lead Mining Company was organized at a capital of $1,000,000, in shares of $1.00 par value, to work this prospect. These shares have been offered to the public, but it must be said that the showings visible on the property hardly justify the optimistic claims of the company, as set forth in their prospectuses.

The Calumet Zinc and Lead Co., which had taken over the properties of the Calumet Metals Co., on Calumet Island have not done any work for two years, and there is no appearance of resumption.

A great deal of development work was carried on by Messrs. Lyall and Beidelman, of Montreal, on the lead and zinc deposits discovered in 1911 in the interior of Gaspé peninsula, in the region of the headwaters of the Cascapedia River. They are situated in the projected township of Lemieux. Messrs. Lyall and Beidelman have leased the ground covered by the mining licenses of the New Richmond Prospecting and Mining Co., and have also acquired mining rights on neighbouring land.

These deposits are situated about forty miles, in a straight line, north of the mouth of the Cascapedia river. By road and trail the distance is fifty-two miles. The work done up to December, 1916 comprises a shaft, 8 ft. by 10 ft., sunk to a depth of 115 feet. This shaft is vertical for 45 feet, where it cuts the vein; it then follows the vein for 70 feet, which dips 80 to 85 degrees E. At the bottom of the shaft drifts have been driven, 174 feet to the south and 166 feet to the north. From the drift cross-cuts have been driven towards the west, to a second vein 120 feet distant from the main vein and parallel to it.

The surface equipment consists of a head-frame and shaft-house, blacksmith and repair shops, office building, boarding house for sixty men, powder house, etc. The hoisting machinery is installed for a depth of 1,500 feet. Power is supplied by two 60-H.P. Waterous boilers. There are also a five-drill Ingersoll-Rand compressor, pump equipment, tracks, ore-cars.

Most of the work has been done on what is designated as "Block H" of the township of Lemieux. But a shaft, 22 feet deep, has also been sunk on "Block D," where a 30-H.P. boiler and a Sampson hoist have been installed.

Development work will be actively pushed during the summer of 1917.

MOLYBDENITE

For the first time in the history of our mineral industry we record this year important shipments of molybdenite, and a great activity in the development of our resources of that substance.

From the shipments of molybdenum ore mined in the Province of Quebec during the year 1916, a total recovery of 129,275 pounds of $Mo\ S_2$ was effected. Practically all of it came from the workings of the mine of the Canadian-Wood Molybdenite Company, situated on lots 9 and 10 range VII of the township of Onslow, usually known as the "Moss" mine.

The demand for molybdenite has been very keen, and this has stimulated prospecting and development in search of this mineral. In the case of the Moss mine above mentioned, the results were almost sensational.

The occurrence worked by this mine had been known for a long time to Mr. Arch. McLean, but simply as an outcrop, and no development whatever was done on it until March, 1916. In that month work was begun and a few weeks later the first carload of ore was shipped to Denver, Colorado, to be concentrated in the plant of Henry E. Wood & Co.

After this, shipments continued regularly to Denver, and to the ore dressing laboratories of the Department of Mines, Ottawa, where three Wood machines are installed, and molybdenite is concentrated on a commercial scale. The Wood water flotation process[1] seems to have given the best results on this ore and it is claimed that recoveries of 80% and more are made on ores running 1% molybdenite. Several carloads of the ore were also shipped to the mill of the International Molybdenum Company at Renfrew.

The Moss mine is situated on lots 9 and 10 of range VII of the township of Onslow. The lot line crosses the main pit near the

[1] See the Wood flotation process. Trans., Amer. Inst. M. Eng., Vol. 44, 1912; also Bulletin III, U.S. Bureau of Mines; Molybdenum, its ores and their concentration, by F. W. Horton.

middle. It is distant about three miles from the station of Quyon, on the Waltham Branch of the Canadian Pacific Railway, thirty-three miles from Ottawa. The character of the deposit has not yet been studied closely, but from a short examination, it is apparently a body of a dark coloured rock, very coarse grained, composed of pyroxene, hornblende, a plagioclase feldspar and some quartz, in a country rock, which is here a flesh-red, rather fine, even grained, compact granite, with slight gneissic texture, rather typical of the Laurentian areas. It has not been determined if this body of mineralized rock is intrusive into the Laurentian, or if it is a highly metamorphosed and altered inclusion representing a pendant, completely enclosed by the invading Laurentian granite.

The molybdenite is found disseminated in the rock in small flakes and in powder. The dissemination is irregular but very persistent, varying from a lean ore of one tenth of one per cent, to highly concentrated nests, or pockets running twenty per cent or more in molybdenite. There is comparatively little waste rock, for very low grade ore (one half of one per cent) can be treated successfully by the Wood flotation machines, at the present high prices obtaining for the mineral. Associated with the molybdenite is found a large proportion of both pyrrhotite and pyrite, but fortunately, there is little mica of any sort, and it does not cause any trouble.

The size and shape of the ore body at the main workings have not been determined. Originally it showed on the surface as a rounded knoll of the coarse grained rock protruding through the fine grained gneissic granite. The pit No. 1, at the beginning of January, 1917, was 115 feet long, 60 feet wide, two-thirds of this area had been excavated to a depth of about 50 feet and the remaining third was down 35 feet. Moreover, prospect pits were put down up to a distance of 800 feet from No. 1 workings and ore struck in all of them. The excavation 800 feet distant from the main workings is called No. 3 pit. It is possible that this may be a continuous body, but whether a dyke, a sheet, a stock or an inclusion is uncertain. That it is a large mineralized body is borne out by the fact that so far there does not seem to be any change in the nature of the deposit or of the ore.

Workings No. 2 are 1,200 feet distant to the north-west of No. 1. They are in the face of a cliff where molybdenite-bearing dark rock appears enclosed, without any definite walls, in the fine grained gneissic granite.

A very complete concentrating mill has been erected on the property. The boilers, 180 H.P., are burning wood for the present. The machinery consists of a jaw crusher, breaking the ore to 1¼ inch size; another reducing it to ¼ of an inch; dryer which feeds a Krupp ball mill of 60 tons per 20 hours, and a Traylor ball mill of 20 tons, both reducing the ore to 20 mesh. The crushed ore is elevated to bins whence it is fed to 8 Wood water-flotation machines. The water supply is piped and pumped from a distance of 1¼ mile.

A second concentrating plant has been installed by the same company at Hull, close to the works of the Canada Cement Company. This second plant consists of nine Wood flotation machines capable of putting through 140 tons of ore a day, or about double the capacity of the concentrator at the mine. The crushing is done by contract by the Canada Cement Company in their tube mills.

The whole output of molybdenite is taken by the Imperial Munitions Board for the British Government at the price set of 105 shillings per unit of molybdenite delivered in England, which corresponds to about $1.00 per pound of molybdenite contents in Canada. The Canadian Wood Molybdenite Company is at present considering the installation of a plant for the manufacture of ferro-molybdenum.

It is probable that the Moss mine was the world's largest single producer of molybdenite in 1916. Considerable prospecting work was done on numerous other molybdenite showings, but apart from shipments of ore, varying from three tons to 800 pounds, for experimental purposes, no other production has been reported.

The following reported work done on molybdenite occurrences during 1916—Geo. A. Dion, of La Sarre; deposit on Indian Peninsula, in Preissac township.

St. Maurice Mines Company, A. E. Doucet, Quebec, president; deposit on Indian Peninsula, lake Keewagama, Preissac township.

The Height of Land Company, 316 St. James St., Montreal; deposit on Kinojevis river, Preissac township.

Chabot & Company, Ottawa; deposit in Huddersfield township, lots 21 and 22, range V.

Aldfield Mineral Syndicate, Chas. G. Ross, 667 Echo Drive, Ottawa; Aldfield township, lots 1, 2, 3, range III, lots 1, 2, 3, range IV.

T. E. Richardson, Portage du Fort, lots 26 and 1a, range XIII, Clarendon township.

W. L. Foley, Quyon; Onslow township, North ½ lot 10, range VII.

It is interesting to mention that the International Molybdenum Company, has erected a custom concentrator at Renfrew, where producers of molybdenite ore can sell their output at the following rates per ton of 2,000 lbs., according to a quotation published in the *Canadian Mining Journal*, in February, 1917:—

Ores carrying between	2 and 3%	$Mo\,S_2$	$14.00	per unit
" " "	3 and 5%	" "	16.00	" "
" " "	5 and 10%	" "	17.50	" "
" " "	10 and 15%	" "	18.50	" "
" " "	15 and 20%	" "	19.50	" "

80% concentrates $1.09 per lb. of $Mo\,S_2$.

Penalties for presence of copper and bismuth.

No settlement made for any molybdic oxide in ores.

Samples of ores to be submitted before any shipment made.

Prices quoted for molybdenite in the United States have been appreciably higher than those set by the British Government. Moreover the supply is very scant. Prices ruling at the beginning of 1917 in New York were from $1.75 to $2.00 a lb. for molybdenite, and $4.00 a lb. for ferro-molybdenum.

In the past the principal countries producing molybdenite have been Australia and Norway. In Australia, Queensland and New South Wales are the main contributors. In 1914 Queensland produced 87 tons of high grade concentrates valued at $185,800, and New South Wales 68¾ tons valued at $55,720. In 1915 the latter's production has fallen to 35½ tons, although the value had increased to $82,415. These productions come from a number of mines, the largest individual one in 1914 having been 20 tons of concentrates from the Murphy and Geaney mine in the Chillagoe field of Queensland.

In Norway the production of molybdenite has been very irregular. The statistics compiled for Bulletin 111 of the U.S.[1]

[1] Horton, Frederick W., Bulletin 111, Molybdenum, ores and concentration, U.S. Bureau of Mines, 1916.

Bureau of Mines give the production for 1910 as 33 tons of high grade concentrates; 1911 as 2 tons; 1912 as 23 tons, and 1913 as 13 tons.

The demand for molybdenite seems to have greatly stimulated the production of Norway, for, according to the *Echo des Mines et de la Metallurgie*, Norway, in 1916, was one of the world's principal producers, as the two mines situated near Knabeheim, north of Flekkerfgord, reported an aggregate of 87 tons of concentrates at 75% Mo S^2, recovered by the Elmore vacuum process.

From the above it may be inferred that the Moss mine, at Quyon, Province of Quebec, the output of which in nine months was about 6,000 short tons of ore, from which was recovered 129,275 lb. of molybdenite, was easily the largest individual producer in 1916.

The following notes on the Queensland production of molybdenite are taken from a paper by Mr. B. Dunstan, Chief Geologist of Queensland. Copious extracts of the article have been reproduced by the *Mining Journal*, London, September 9th, 1916.

> "The principal molybdenite lodes are at Wolfram, in the Chillagoe mining field of Northern Queensland; other important deposits occurring at Bamford, in the same district. Areas where the mineral is also being mined include Sandy Tate River, in the Chillagoe field; Kidston, in the Etheridge goldfield; Ollera Creek, in the Star mineral field, near Townsville; and Stanthorpe, near the New South Wales border. Other areas in the Chillagoe and Herberton mineral fields, and also at Rosedale, to the North-West of Bundaberg, contain a number of molybdenite deposits which are being prospected. Official records also show common occurrences of the mineral in small quantities in quartz lodes on many of our gold and mineral fields.........
>
> "Molybdenite generally occurs as flakes or laminated crystals in lodes, pipes, or irregular masses of quartz in a greisen formation, the country rock being generally granite, with porphyry or altered sedimentary rocks in the immediate vicinity. The principal associated metallic minerals are molybdite (the yellow oxide), wolfram, native bismuth, and pyrites, with many metallic and nonmetallic minerals of no economic importance also present. Molybdenite very frequently occurs with pyrites, less frequently with wolfram, and

only occasionally with native bismuth. Masses of molybdenite, wolfram and native bismuth are sometimes to be seen intercrystallized with quartz, but the molybdenite also occurs as large flaky six-sided crystals in drusy quartz cavities or pipes without the presence of any other minerals.

"In prospecting for molybdenite experience has shown that irregularity in the form of the lodes is a persistent characteristic. Often the lodes are exposed as large isolated "blows" of white quartz within a narrow belt of granite country, but they are sometimes to be observed outside this belt of granite in the adjacent sedimentary rocks. There seems to be a general tendency to over-estimate the importance of molybdenite-bearing outcrops, and the appearance of a few bright lead-grey cleavable scales in a quartz outcrop, while not to be ignored, must not be taken as an indication of a rich discovery. On the other hand, some of these quartz "blows" show no tract of molybdenite on the surface, but in being worked for other minerals have occasionally developed into productive molybdenite deposits."

"*Production.*—Queensland's production of molybdenite in 1915 amounted to 97¼ tons, valued at £45,060, which constitutes a record as far as values are concerned, but the yield is smaller than that of several previous years, the production of 1916 being the largest, with an output of 106 tons. The total yield of molybdenite up to the end of 1915 amounts to 1,098¾ tons, the production being valued at £208,097. These figures have been worked out from the returns published in the annual reports of the Mines Department, but are exclusive of the returns of quantity and value of some other minerals which therein have been incorporated with those of molybdenite."

"Ferro-molybdenum quotations (April 1916) show that this alloy, when containing from 70 to 80% of molybdenum, is sold at prices varying from 12s. to 18s. per pound, this being at the rate of from £1,904 to £2,016 per ton. The quantity of the sulphide necessary to make one ton of ferro-molybdenum varies from 1,1-5 to 1,2-5 tons, according to quality, the value of the mineral varying between £612 and £714 per ton, the difference between the costs of the raw material and the selling prices of the ferro-molybdenum, roughly £1,300, being manufacturer's costs and profits. The State's production of molybdenite in 1915, as stated above amounted to 97¼ tons, valued at £45,060, which would make about 80 tons of ferro-molybdenum, valued at about £155,000. We have, therefore, one year's yield of a little less than 100 tons of molybdenite delivered in London on which the ferro-mloybdenum manufacturers' costs and profits amount to over £100,000, or at the rate of £1,000 per ton."

GOLD AND SILVER

The small production of gold and silver is to be credited to the copper-bearing pyrite ores of the Eastern Townships and to the zinc and lead ores of Portneuf county, as no precious metal ores proper are at present worked in the Province of Quebec.

Nevertheless considerable work has been done in prospecting and development on the deposits of gold-bearing quartz of Dubuisson township, south of the Transcontinental Railway, in the Abitibi district. These occurrences were examined by Dr. J. A. Bancroft and described in the "Report on the Geology of head-waters of the Harricana river." (Mining operations in the Province of Quebec in 1912.)

The rocks of the district consist of; (1) a large development of the Keewatin formation which "comprises a complex of igneous rocks of both extrusive and intrusive types. Ancient lava flows, varying in petrographical character from rhyolites to basalts, have been more or less altered to different varieties of schists: chlorite, sericite, actinolite, and hornblende schists." (2) Rocks of Laurentian age, "granites and those rock types which plainly have been evolved from the differenciation of a granitoid magma." They "occur in batholiths and stock like intrusions of granite, syenite and granodiorite with allied dyke rocks." (3) Dykes of "newer diabase" and of a contemporaneous rock, a syenite porphyry, which consists of a fine dark ground mass, in which are embedded large crystals of orthoclase feldspar. The diabase and the syenite porphyry are the youngest rocks of the area, and were probably the mineralizing agents of the metalliferous deposits of the district.

Since the staking of the early mining claims, the township of Dubuisson has been subdivided into lots, and the claims on which most work has been done are the following:—

J. J. O'Sullivan, which comprise parts of lots 48 to 51, range IX and lot 53 range X.

Messrs. Stabell and Clark's claims, parts of lots 52 to 56 ranges VIII and IX.

O. Leblanc's claims, parts of lots 36 and 37, range VIII and block A range IX.

On O'Sullivan's claims, four veins of quartz traversing granodiorite have been exposed, one of which has been uncovered for about 600 feet. Much stripping has been done on all of them showing widths varying from a thin stringer to eighteen and twenty inches. Several assays of samples collected in 1912 by Dr. Bancroft yielded up to $118 in gold per ton. A characteristic of one of the veins in this claim is the presence of much tourmaline, both in masses and in fine needles, and with much of this mineral gold is associated.

The veins on the Stabell and Clark claims are near the contact between the Keewatin schists and Laurentian granodiorite. They appear to be promising though very little work had been done up to August, 1916. Since then, however, the work has been pushed actively, two shafts have been started and some stripping and trenching has been done.

On Leblanc's claim the vein had been stripped for several hundred feet. This deposit consists of lenses of quartz in a sheared zone of Keewatin rocks, near the contact with syenite porphyry.

The district is promising, and in his report on the field work done in 1912, Dr. Bancroft speaks of it as follows:—

"Considering the discoveries of gold which have been made in the vicinity of Kienawisik (now De Montigny) lake, diligent prospectors should carefully examine every acre in this vinicity with well founded expectation that much better discoveries may be made. Until no stone has been left unturned, this area offers more reasonable hopes of reward than those vast expanses of country within which no discoveries have been made. Prospecting should not be concentrated only in the immediate vicinity of Kienawisik (De Montigny) and Blouin lakes, but should be extended to adjacent areas, especially to the eastward and westward of those two lakes, and of the narrows extending to Lemoine lake. Where schistose, the bands of rock within this portion of the area are striking S15° to 25° E."

MAGNESITE

Very active development and exploitation were carried on, on the magnesite deposits of Argenteuil County. The shipments reached 53,976 tons, representing a value of $525,966, as compared with 16,285 tons valued at $137,353 in 1915.

The North American Magnesite Company is as yet the only one operating a calcining kiln, and a short description of their plant was given in our last year's report. They operate on lot 15, range IX. of Grenville township, this quarry and calcining plant being about ten miles distant from the railway station of Calumet. The magnesite is hauled that distance by teams.

The Scottish-Canadian Magnesite Company has also been in continuous operation all year. The quarry is situated on lots 15, and 16, ranges X. and XI., and is well equipped with modern machinery. It is 12 miles from the C.P. railway and all the hauling from the quarry to the railroad has previously been done by teams. But during the year a subsidiary company, the Dominion Timber and Minerals, Limited, was organized for the purpose of building a narrow gauge railroad to connect the quarry and the C.P.R. In December the road was almost completed. It is 13 miles long and when in operation will greatly facilitate the shipment of magnesite, as the roads in that part of the country are very bad and hilly. It is intended to convert this narrow gauge into a standard gauge as soon as it will be justifiable, and the road-bed was constructed with that object in view.

Messrs. Fitzsimons and Boshart, of Ottawa, carried on some development work on lots 15 and 16, range VIII., of Grenville, but did not make any shipments.

The magnesite deposits of Argenteuil county have been known since 1900, but it is only in 1908 that work was started on them on a small scale, the product being used in the manufacture of carbonic acid gas and for flooring cements. The cutting off of the Austrian supply of magnesite in 1914 directed the attention on the Argenteuil deposits as a substitute in the manufacture of refractory brick and linings for metallurgical furnaces. As a result, the production has increased from 500 tons in 1913 to nearly 54,000 tons in 1916.

A.—Magnesite. Quarry No. 2 of North American Magnesite Co., lot 15, range IX, township of Grenville.

B.—Magnesite. Quarry and picking platform of Scottish-Canadian Magnesite Co. Ltd.; lots 15 and 16, ranges X and XI, township of Grenville.

The magnesite deposits occur in the bands of crystalline limestone of Grenville age, which are so numerous dotting the Laurentian area north of the St. Lawrence and Ottawa rivers. The rocks of the Grenville series are the oldest observed in the region, and they are described as follows by Dr. M. E. Wilson, who in 1914 and 1915 worked out the geology of the Buckingham map area, immediately to the west of the Argenteuil sheet.[1]

"The oldest rocks to be found in the Buckingham map area belong to a group of highly metamorphosed and crumpled sediments which are generally known as the Grenville series. It is believed that the rocks of this series were originally laid down as alternating beds of shale, sandstone and limestone; but owing to the contact and regional metamorphism to which they have been subjected, the limestone has been converted into crystalline limestone, the sandstone to vitreous quartz, and the shale to sillimanite-garnet gneiss. The reasons for this conclusion are two-fold: (1) the chemical analysis of the sillimanite-garnet gneiss has shown it to have the chemical composition of a shale and thus the three rock types—sillimanite-garnet gneiss, quartz rock, and crystalline limestone have respectively the composition of the three dominant members of normal sedimentary series and (2) these rocks occur interstratified with one another in a manner similar in every respect to the way in which normal bedded deposits usually occur."

During the field season of 1916 Dr. Wilson's work was extended so as to take in the magnesite deposits of Argenteuil county. From a critical study of these he thinks it possible that they may owe their origin to a replacement process by which the carbonate of magnesia of mineral solutions circulating in and acting on the crystalline limestone, was exchanged for the original carbonate of lime of the rock. If such be the case all gradations from calcite to magnesite might be expected to be found in these bands of the Grenville series and this has repeatedly proved to be the case.

The magnesite deposits therefore need not be limited to any definite area of the Grenville rocks and they are liable to occur in any patches of this series throughout the southern fringe of the vast Laurentian expanse, which constitutes the Pre-Cambrian shield, where the replacement process of the magnesian solutions has been sufficiently active to change the limestone into the gradations of magnesian limestone, dolomite and magnesite. Following

[1] See summary report—Geological Survey for 1915, page 158.

up this theory, it is interesting to note that the stone quarries opened up in bands of Grenville rock, at Portage du Fort and at Bryson, one hundred miles in a straight line from presently worked magnesite deposits, give on analysis contents of 43.12 and 44.96% respectively of carbonate of magnesia.[1]

A great deal of prejudice existed at first against using the Grenville magnesite as furnace lining. It was said that high contents of lime prevented it from binding, and that the linings made of it easily crumbled. From experiments carried on in actual metallurgical practice, very satisfactory results have been obtained by adding to the magnesite 15% of basic blast-furnace slag. The iron of the slag supplies the bond necessary to agglomerate and set the material. Austrian magnesite contains between 6 and 10% iron.

To be used as refractory lining, the magnesite has to be dead-burned, that is practically all the carbonic acid must be expelled. For this, the calcining has to be carried further than for the ordinary calcined magnesite, as used for Sorel cements, which contains up to 8% of carbon dioxide. For dead-burned magnesite the calcination has to be carried to the point of incipient fusion, in the vicinity of 2900°F.[2] The shrinkage due to the calcining, is then taken up, and the product resulting is a very dense, fire resistant and chemically inactive substance.[3] It is a question whether the prejudice which seems to exist against the Grenville magnesite is not, to some extent, due to imperfect "dead-burning". The essential differences between Austrian magnesite and Grenville magnesite are that the former contains 3 to 5% lime and 6 to 8% iron, and the latter 6 to 12% lime and practically no iron.

MICA

We record a substantial increase in the shipments of mica in 1916 as compared with 1915. The value totalled $177,814 instead of $55,897 for the previous year. The market for mica was much better than in 1915 and the ruling prices more satisfactory. Still mica mining was not as active as the increase in the sales of mica would lead to believe, for a considerable proportion came from stock

[1] Limestones in the Province of Quebec, by H. Frechette, Summary Report of Mines Branch, Department of Mines, Ottawa, 1914.

[2] Metallurgical and Chemical Engineering. Feb. 15th, 1917.

[3] Mineral Resources, United States Magnesite, in 1914.

on hand which had accumulated during the last two years, waiting for better prices.

United States and England are the two countries where the greater proportion of our production of mica is exported.

The average prices which prevailed during 1916 for standard sizes of mica, thumb-trimmed, were as follows:—

	Per lb.
1 x 1 inch	5½ to 6½c
1 x 2 "	11 to 14c
1 x 3 "	16 to 20c
2 x 3 "	40 to 45c
2 x 4 "	65c
3 x 5 "	90c
4 x 6 "	$1.25

The war conditions seem to have affected the mica market adversely during the first eighteen months, but the demand is now improving considerably. As for other goods, the shortage of sea transportation facilities greatly handicaps the industry.

India and the United States are the two other important producers of mica. Both produce muscovite almost exclusively, whereas Canada produces phlogopite or amber-mica. Phlogopite is superior to muscovite in the construction of electrical apparatus, owing to its greater elasticity and easy cleavage into thin sheets. Owing to its qualities phlogopite commands higher prices than the muscovite of the same size.

It is very difficult to give systematic statistics of the mica production owing to the diversity of products and the divergence in prices. The mica is marketed in several forms of which the principal ones are thumb-trimmed mica, thin split mica, scrap mica and pulverized mica. Scrap mica and pulverized mica bring from ¾ to 1½c a pound, whereas the large sizes of thumb-trimmed mica go as high as $1.50 a lb. The thin-split mica, which is split into sheets one to two thousandths of an inch in thickness, or about the thickness of ordinary paper, represents a further stage of preparation, and the value is thus further enhanced. Our figures of production comprise all classes of mica, for it is often difficult to differentiate them from the reports, and in this respect the figures are unsatisfactory. For instance in the production for 1916, are included some 300 tons of scrap mica which represent an average value of about $20.00 a ton, as well as mica at $1.50 a lb.

The mica produced by the Province of Quebec is exclusively phlogopite, or amber-mica. The principal mica district comprises the region north of the Ottawa river, between the valleys of the Gatineau and of the Lièvre rivers. Mica occurrences, however, are known in many other parts of the province, and some of these have been worked, but in the last two years, working mines have been confined to the Lièvre and Gatineau rivers district.

An idea of the fluctuation of the demands for mica may be gathered from the value of the production of the Province for some years back, as compiled from the past annual reports of the Quebec Mines Branch:—

VALUE OF THE PRODUCTION OF MICA IN THE PROVINCE OF QUEBEC FROM 1897 TO 1916.

1897	$ 50,000	1907	$ 223,878
1898	81,000	1908	95,311
1899	136,863	1909	27,034
1900	163,600	1910	51,901
1901	39,600	1911	76,428
1902	34,304	1912	99,463
1903	74,119	1913	117,038
1904	85,024	1914	67,278
1905	95,460	1915	55,897
1906	168,887	1916	177,814

KAOLIN

The kaolin industry in St. Rémi d'Amherst had until last November, been much hampered and handicapped by the lack of means of transportation. The mine and washing works of the Canadian China Clay Co. were situated at a distance of eight miles from the nearest railway station, at Huberdeau, and the kaolin had to be hauled by team over very indifferent roads. But in 1916, a spur was completed from Huberdeau on the Canadian Northern Railway, connecting the railway and the washing plant, and the shipments can now be made direct.

A.—Open-cut No. 1 in Kaolin deposit.—Canadian China Clay Co., lot 5, range VI south, St. Rémi d'Amherst.

B.—Kaolin washing plant.—Canadian China Clay Co., St. Rémi d'Amherst.

The kaolin produced in 1916 was washed material, shipped to paper manufacturers for filler, and according to the report received at the Mines Branch, the demand greatly exceeded the ability to supply the material. Important alterations are being made in the washing plant, and with the shipping facilities now available, a much increased production is soon expected.

Steps are being taken to develop the fire-clay and the silica branches of the undertaking.

The main pit of the Canadian China Clay Company is situated on lot 5, range VI S., of Amherst township, but the presence of kaolin has been observed on most of the lots from 2 to 10 of this range. A new pit has been started on lot 6 on what appears to be the southern extension of the deposit worked by the main pit.

The kaolin is worked by hydraulicking. A Worthington pump of a capacity of 1,000 gallons a minute supplies the water which issues through the nozzle under a pressure of 100 lbs. breaks down the bank, and the liquid mud is siphoned down to the washing plant, into settling tanks, and after the clay has settled, the water is used anew for the hydraulic operations.

This occurrence of kaolin is the only workable one known in Canada. A detailed description of the deposit was given in the Report on Mining Operations in the Province of Quebec for 1914. Results of tests and analyses on material from this deposit were given in the Report on Mining Operations in 1915.

FELDSPAR

The production of feldspar shows an appreciable increase, having reached a total of 4,606 tons, valued at $20,760. This comprises a small quantity of very pure feldspar produced at the old Villeneuve mine, lot 31 range I, Villeneuve township, which is used in the manufacture of artificial teeth and which brings high prices,—$15 to $20 a ton in lumps.—The bulk of the feldspar, however, is used in the ceramic industry, porcelain manufacture, enamel ware, sanitary pottery, glazed or enameled brick. Practically the whole of the Quebec production comes from the Buckingham district, and is exported to the United States.

The mineralogical term feldspar comprises a great number of minerals, silicates of aluminium, with one or more of the three bases potassium, sodium, calcium. But industrially, the term feldspar is restricted to the members of the family which contain potassium, *i.e.* orthoclase and microcline.

Orthoclase is a common mineral; an essential constituent of all granites, but it can only be mined when it occurs in bodies which can easily yield large quantities of comparatively pure feldspar, for it is a low priced material which cannot stand high costs of preparation or of transportation.

The province of Quebec possesses practically unlimited deposits of feldspar in the numerous pegmatite bodies which dot the precambrian shield, from the Ottawa and St. Lawrence rivers to Hudson strait, but only the most favourably situated could ever be of economical value.

In his report on "Feldspar in Canada"[1] Mr. DeSchmid describes twenty-six deposits of feldspar in the province of Quebec on which some work was done, and which yielded good material, situated in the following townships, Bouchette, Buckingham, Hull, Portland East and West, Templeton, Villeneuve, Wakefield, Waltham, Maisonneuve, Lacoste, Bergeronnes, Tadoussac and in Mingan seigniory. The above shows how widely this material is distributed in the province, in presumably, workable deposits.

Dr. W. E. Wilson of the Geological Survey, who is now engaged in mapping the geology of the region north of the Ottawa river, east of the Gatineau, makes the following remarks regarding the occurrence of feldspar:[2]

"Throughout the whole of the Pre-Cambrian portion of the Buckingham area, there is scarcely a square mile of territory in which a mass of pegmatite of considerable size is not present, so that the possibilities of this district as a source of feldspar are almost unlimited. Since, however, the value of a feldspar deposit is dependent on a great variety of factors such as, the potash content of the feldspar, the absence of impurities in the feldspar, the uniformity in composition of the product shipped, the coarseness of crystallization of the pegmatite, the proportion of waste rock to be handled, the location of the deposit, cost of labour, and cost of transportation, it is obvious that the best occurrences of pegmatite from which feldspar can be mined, can only be located by the systematic

[1] H. S. De Schmid—Feldspar in Canada, Mines Branch, Department of Mines, Ottawa, 1916.

[2] Summary report Geological Survey for 1915, page 162.

prospecting of the most easily accessible portions of the area. If this method was adopted, numerous other deposits equally as good or possibly better than those which have been worked in the past, might be discovered."

Since the outbreak of European hostilities, prominence has been given to the question of extracting potash from feldspar, owing to the cutting off of the products of the German potash mines, whence came practically, the world's supply. In his report on "Feldspar in Canada," H. DeSchmid briefly describes sixty different processes, which have been patented, for rendering soluble the potassium contents of silicates and extracting it. These processes, however, are based on a fusion of the silicate, together with substances to react on the potassium and form new compounds soluble in water, and such processes, while feasible if the prices of potash remained anywhere near their present level, could not possibly compete with prices which prevailed for the natural products before the war.

One of the largest known deposits of feldspar in the province, is that situated in the Mingan seigniory, on Manicouagan peninsula, 325 miles below Quebec. Mr. De Schmid[1] describes it as follows:—

"The property is at present owned by the Canadian Feldspar Company, of Montreal, who acquired the deposit a few years ago. Beyond shipping a small trial consignment of about 30 tons to the potteries at Trenton, N. J., and also to England, the owners have carried out no work. The property was leased in 1912 to a syndicate, who, however, did little beyond prospecting work, three men being employed for a couple of months in surface stripping. Several hundred tons of spar were lying at the quarry when the property was visited, but none had been shipped. A quantity estimated at about 200 tons is reported to have been taken out as far back as 1899, but no record of shipment is obtainable; the mineral at present lying on the property probably includes this output. No machinery has ever been employed, though the present owners purposed installing a boiler and steam drill, part of the equipment being ready to ship in the latter part of 1912. The entire work so far performed consists solely of stripping off the thin overburden of moss and soil which covers a great part of the deposit, and of blasting out the purer spar exposed to the surface.

[1] Feldspar in Canada, Department of Mines, Mines Branch, Ottawa, 1916.

"The deposit consists of a pegmatite body composed of microcline feldspar and quartz. The feldspar is of light cream colour, and occurs locally as large individual crystals scattered through a matrix of more or less coarse-grained graphic-granite; the usual mode of occurrence, however, is in small individuals, graphically intergrown with quartz. The large individuals frequently yield plates or slabs of pure spar up to 18 inches in length. The proportion of feldspar to quartz in the dyke is sufficiently large, were it not for the presence of injurious accessory minerals in the dike mass, to permit of a large amount of the mineral body being shipped crude with a minimum of hand-cobbing, the percentage of quartz in several zones in the dike averaging under 10 per cent. The amount of quartz present in the graphic-granitic zones would average around 25 per cent; while probably ten per cent of the run-of-mine would represent clean spar. Whether these conditions would persist in depth can only be determined by actual development. The pegmatite body, however, is of sufficient width to warrant the assumption of approximate homogeneity throughout its mass to a considerable depth."

"The spar belt on this property has a width of about 200 feet, and has been stripped over an area of 100 x 900 feet. The dike probably extends for a considerable distance shorewards—the average height of the peninsula above high water level is 30 feet, and, as deep water extends right up to the deposit, loading of the mineral into the barges should present no difficulties. Good anchorage exists, the inlet being narrow and well protected from storms. Freight rates to Trenton, N.J., have been estimated at about $2.00 per ton.

"An analysis of picked spar—that is, of mineral unmixed with quartz, etc.,—from this property yielded:

Silica	64.60
Alumina	19.24
Potash	11.75
Soda	3.41
Ferric oxide	0.23
Water	0.21
Total	99.44

"The melting point was determined at 1317°C. A sample of the graphic-granite has also been analysed and found to contain:

Silica	74.00
Alumina	14.23
Potash	8.80
Soda	1.96
Ferric oxide	0.07
Water	0.18
Total	99.64

"This analysis would show a percentage of nearly 29 of quartz to 69 of feldspar, a ratio which would have to be adjusted by the addition of hand-picked feldspar were the mineral to be utilized for pottery purposes.

"A further analysis of a selected sample of spar from this deposit, conducted by N. L. Turner, of the Mines Branch, in 1914, as follows:

SiO_2	64.78
Al_2O_3	18.05
Fe_2O_3	0.46
FeO	0.03
CaO	0.40
MgO	0.02
Na_2O	2.72
K_2O	13.80
H_2O	0.12
BaO	0.01
Total	100.39

"This analysis shows over 2% more potash than the first of the preceding ones."

Quebec. Bur. Min., 1899, p. 27; 1911, p. 32.

Can. Min. Journ., Jan. 1, 1911, p. 27.

GRAPHITE

The shipments of graphite from the mills in operation in the Province of Quebec in 1916 amounted to 957,100 lbs., valued at $75,776. This is the highest production yet recorded and the figures are very gratifying.

The Quebec graphite industry has had a very checkered career since its inception in 1847, when several tons of graphite were mined from a deposit in Grenville township.

The fluctuations of the production are well illustrated by the annual figures for the last 15 years.

VALUE OF THE ANNUAL PRODUCTION OF GRAPHITE FROM 1899 TO 1916

Year	Value	Year	Value
1916	$75,776	1907	$5,000
1915	2,416	1906	8,300
1914	18,886	1905	Nil.
1913	9,620	1904	2,300
1912	50,680	1903	Nil.
1911	33,613	1902	2,160
1910	15,896	1901	4,690
1909	10,339	1900	9,464
1908	165	1899	5,100

The graphite deposits of the Province of Quebec consist of sillimanite gneisses and crystalline limestones of the Grenville series, representing highly metamorphosed sediments of Precambrian age, throughout which occurs disseminated graphite in flakes. The proportion of graphite varies up to a maximum of 30% or more, and the average ore contains from 8 to 15%. The great difficulty which has all these years been the cause of so many failures, resulting in numerous abandoned mines and mills, has been the concentration of the graphite and the elimination of the accompanying minerals more especially mica. Graphite deposits are numerous and have been worked in the townships of Grenville, Buckingham, Lochaber and Amherst. Other occurrences are known in Cameron, Hull, Wakefield, Portland, Wentworth, Bryson, and others.

The New Quebec Graphite Company were in operation during the greater part of the year and have reported very substantial shipments. This company took over the properties of the Quebec Graphite Company, which were described in our annual report for 1914. The deposits worked are on lots 1 to 4, range IV, of Buckingham township, but the company also owns some deposits on lot 28 range IV of Lochaber.

Another important producer in 1916 was the Plumbago Syndicate, who took over the properties of the Dominion Graphite Company. The main deposit of this company is on lots 20 and 21 range V of Buckingham.

Graphite Limited, who began mining operations in 1909 on a graphite deposit on range VIII of Amherst township, went into liquidation in 1916, but a working option was obtained on a royalty basis by the Multipar Syndicate who report small shipments from their operations. Apparently the results obtained were not satisfactory, as the option was not exercised.

NATURAL GAS

Very little further development was done in the St. Hyacinthe county gas-field since our last report, and what was done does not seem to have borne out the rather sanguine expectations of the operators. The fourth well of the Canadian Natural Gas Company, which had reached a depth of 2,450 feet in December, 1915, was continued a little further down, but eventually all work was stopped and had not been resumed in January, 1917.

The National Gas Company of Canada which control part of the field, put down a second well on lot 1319, range St. André, 1800 feet north of the first mentioned in our last year's report, but without getting definite results.

In our report for 1915 we pointed out that although high rock-pressures had been obtained in the wells put down, this was no sign of the permanency or continuity of the flow. We were urging then to make systematic determinations and gaugings of the flow of the various wells, to have something definite on which to base the claims put forth in prospectuses.

However, we are not aware that this has been done, and it is possible that the gas struck so far at various depths may be in limited pockets, and there does not seem to be yet any assurance of permanency of flow.

The covering of the Trenton is here much thicker than it was anticipated when prospecting was begun. The drift is very heavy, exceeding 100 feet in many cases, and the outcrops are few. So that in the absence of borings, the thickness of the underlying formations could only be surmised from observations in neighbouring regions. In Ontario, for instance, a maximum thickness of 1,300 feet has been assigned to the shale beds of the Lorraine and Utica lying between the top of the Trenton and the base of the Medina. The deepest boring of the Canadian Natural Gas Company has penetrated 3,455 feet into these overlying shale beds, without any change of character indicating the possible approach of the Trenton limestone; the conclusions concerning their maximum thickness will therefore have to be revised.

The presence of a permanent source of natural gas has not yet been demonstrated in this field, and for a conclusive test, a well would have to be put down to the Trenton formation, which is here overlain by more than 3,455 feet of shales, in which exist pockets of gas.

Raising money for such a test would be quite legitimate, on the understanding that the venture is of a speculative nature. But nothing has yet been demonstrated which would in any way justify the rise, in 1916, of the stock of a company, to $2.75 a share, on the New York curb, for $1.00 shares.[1]

There are two companies operating in this field: One of these, The Canadian Natural Gas Corporation, capital $1,000,000, has two subsidiary companies. "The Canadian Natural Gas Company $2,000,000. and the "Natural Gas, Light, Heat and Power, Limited, $500,000; the other is the National Gas Company of Canada, capital $125,000.

MINERAL PAINTS

Ochre and Iron Oxide

The shipments of ochre and natural iron oxide totalled to a value of $62,875. The quantity shipped was 9,368 tons of 2,000 lbs. This comprises both the calcined material used for the manufacture of paint, and the natural ochre, or oxide of iron, used in

[1] The Financial Times, Montreal, April 14th, 1917.

gas manufacture and in paper manufacture. The average price of the calcined material was $18.35 a ton, and the crude material about $3.00 a ton.

There are numerous deposits of ochre and iron oxide in the Province of Quebec, but only a few are worked.

In 1916 returns of production were received from four producers, three of whom were working deposits in the Three Rivers district, on the north shore of the St.Lawrence river, and a fourth had reopened some deposits in the township of Iberville, on the north shore of the St. Lawrence, some 175 miles below the city of Quebec.

The ochre, or hydrated iron oxide, mined in the Province of Quebec, is very high grade. After calcination the material assays from 90 to 98 iron oxide. A considerable proportion is used in the manufacture of paints, the shades varying from a light yellow to deep red, and owing to the cost of preparation, the value of the ochres used for paints greatly exceeds that of ochres used in gas purifying and in the paper manufacture. In point of tonnage, however, more is used in the raw state.

In gas works the hydrated iron oxide is used to remove the hydrogen sulphide from the gas. For this purpose it is mixed with saw-dust, to render it more porous, and placed in closed vessels through which the gas is made to travel by an inlet and an outlet pipes.

Barytes

No barytes (barium sulphate or heavy spar) has been mined in the Province of Quebec since 1903, when the Canada Paint Company abandoned the deposit of heavy spar which they had been working on lot 7, range X, township of Hull. Work was discontinued there because the vein gave out. This substance is now much in demand. Formerly it was used as an adulterant added to white lead in large proportion, but gradually barytes as a pigment became to be recognized as possessing advantages, and the prejudice against it disappeared. The addition of barytes to white lead adds greatly to the lasting power of a paint, and it takes colour stain very uniformly, thereby being valuable as a base for evenly conveying pigments.

Barium sulphate is the main constituent of the white pigment

Lithopone, which is composed of 70 per cent barium sulphate, 25 to 28 per cent zinc sulphide and the balance in zinc oxide.

Numerous enquiries have been received by the Mines Branch as to the occurrence of barytes in the Province of Quebec, and in this connection, it may be interesting to mention a deposit which was brought to our attention last year. On lot 14, range III of Onslow township, about one mile east of the village of Quyon, occurs a vein in which is found an association of barite and fluorite. The width of the vein is four feet, very constant. The barite is reddish, shows banding and is rather impure. The country rock is limestone, probably of Calciferous age, in beds very little disturbed. The strike of the vein is sensibly east and west, and it dips about 80° south. It is said to have been traced through the width of four lots. On lot 12, range III, an outcrop of probably the same vein, has been stripped for a length of 50 feet, and the characteristics are the same as the occurrence on lot 14: width 3 or 4 feet, strike east and west, but the barite seems to be whiter.

The barite could not probably be used for paint manufacture without treating it to remove the foreign material and bleaching it afterwards by sulphuric acid, to remove the coloration due mainly to iron oxide.

ALUMINIUM

The aluminium industry in Canada is essentially a metallurgical one, and not a mining one. Aluminium is produced by one plant in Canada, and all the ores used by the Northern Aluminium Company, a subsidiary of the Aluminium Co. of America, at their reduction works at Shawinigan Falls are imported, but it is nevertheless interesting to mention the fact that the Province of Quebec is one of the world's important producers of aluminium metal.

In 1913, the imports of alumina (ore of aluminium) into Canada were 15,352 tons and the exports of aluminium metal, in ingots and bars were 6,507 tons. In 1916, the imports of alumina were 25,754 tons and the exports of metal in bars and ingots were 9,213 tons.

In European practice the average production of the reducing works is 300 kilograms of metal per kilowatt-year, which corresponds to 500 lbs. per horse-power year.

BUILDING MATERIALS

The building materials, comprising stone, lime, sand, brick, and other clay products show a marked decrease as compared with 1915. Under the present economic conditions, such a falling off was to be expected. From a total value of $6,242,234 in 1915, the production fell to $5,278,486 in 1916. The main diminution has been in limestone and in cement, the former showing a decrease of $851,196. It may be said however, that a large proportion of this falling off in the production of limestone is attributable to the reduction in road construction in the City of Montreal and immediate surroundings. For several years previous to 1916 very large quantities of crushed limestone from the quarries on the island of Montreal and Isle Jésus (Trenton and Chazy limestones) had been used. Nevertheless the building operations in the Province of Quebec have been considerably affected. This is shown by the following table, which, indicates, as might be inferred, that the issuance of building permits is closely proportional to the figures of production of building materials.

Table of Building Permits, and the Production of Building Materials, in the Province of Quebec, since 1909.

Year	Building permits issued in principal towns.	Production of Building materials
1909	$17,673,070	$2,874,118
1910	23,604,364	4,202,751
1911	23,716,414	5,138,372
1912	37,180,147	7,196,154
1913	38,158,663	8,186,917
1914	26,046,258	7,799,290
1915	12,688,414	6,242,234
1916	10,585,401	5,278,486

Limestone is quarried in the Province of Quebec mainly from the Trenton formation and also from the underlying strata of Chazy age. Physically the two stones are alike. The main centers of production are, Montreal, St. Martin, St. Vincent de Paul, St. Francois de Sales, Hull, St. Marc des Carrières, Château Richer, St. Dominique, but limestones are of wide occurrence in the settled parts of the Province and small quarries and lime kilns, to supply local wants, have been opened in numerous places.

Granite comes next in importance as a building stone. It is quarried: (1) In the Laurentian area, north of the Ottawa and St. Lawrence rivers, from the wide spread occurrences of intrusive rocks, which yield stone of various colours, red, grey, almost black; (2) from the younger granites which protrude through the Ordovician rocks of the Eastern Townships; these yield grey granites almost exclusively. The main centers of granite quarrying in the Province of Quebec are: Rivière à Pierre, Staynerville, Stanstead, Mégantic.

Sandstone is not quarried to any great extent in the Province of Quebec, although it occurs in workable beds in various places. It is in the vicinity of Quebec that most sandstone has been quarried; this has been obtained from the sandstone beds of the Sillery formation, which yield various tints of stone, the prevailing one being greenish. The fortification walls of the city of Quebec, the lower part of the Provincial Parliament buildings, the citadel are built of Sillery sandstone.

Sandstone is also quarried in Beauharnois, from Potsdam beds and in the Gaspé peninsula from Devonian beds.[1],

Mr. Howells Fréchette, of the Department of Mines, Ottawa, has made an investigation of the composition of the limestones of the Province of Quebec and the following table is compiled from the results of the analyses of the samples which he obtained from quarries and occurrences, as published in the Summary reports for 1914 and 1915, of the Mines Branch, Canada Department of Mines, Ottawa. The analyses which were made by Mr. H. Leverin of the Mines Branch, number over two hundred, and the investigation is a very valuable contribution to the knowledge of our mineral resources.

In the table, we have only given the analyses of limestones which gave over 95% of carbonate of calcium, or over 30% car-

[1] A valuable and exhaustive report on the building stones of the Province of Quebec has been published by the Canada Department of Mines, Mines Branch, Ottawa.

bonate of magnesium, that is to say limestones which are above the average in lime, or in magnesia.

TABLE OF ANALYSES OF LIMESTONES FROM THE PROVINCE OF QUEBEC HIGH IN LIME OR IN MAGNESIA

From Investigation of the Limestones of Quebec by Mr. Howells Frechette

	Insoluble	Ferric Oxide	Alumina	Calcium Carbonate	Magnesium Carbonate	Carbon Graphite
Portage du Fort Quarry—Pontiac Marble and Lime Co	0.15	0.22	0.06	57.14	43.12	....
Aylwin Tp., Lot 16, Range III—Crystalline limestone	1.42	0.14	0.04	95.09	2.38	0.42
Grenville Tp., Lot 15, R. IX, North American Magnesite Co	2.20	0.13	0.03	15.71	82.18	....
Grenville Tp., Lot 18, R. XI	1.67	0.17	....	13.21	88.23	....
Lachute, Farm of Geo. Fraser	18.80	0.55	1.45	45.44	33.15	....
Ste Therese.—Quarry Plecide Sanche	1.90	0.70	0.16	94.64	2.38	....
Ste Therese.—Quarry J. F. Pare	13.84	1.21	0.21	49.91	34.36	....
Montreal Island, Village Belanger—Quarry Joseph Monette	1.44	0.64	0.12	95.93	1.58	....
Cap St. Martin, Quarry Th. Saumure	1.30	0.50	0.14	95.98	1.58	....
Godmanchester Tp., Lot 416, Quarry O'Connor Bros	3.40	0.86	0.60	52.53	41.80	....
Godmanchester Tp., Quarry Ross, Church & Co	15.30	0.86	0.38	45.53	36.62	....
Philipsburg, Quarry Missisquoi-Lautz Corporation	1.14	0.14	0.06	96.25	1.44	....
Stanbridge Tp.—Lot 6, Range VII	0.40	0.07	0.04	98.75	1.21	....
Stanbridge Tp.—Lot 2, R. IX.—E. H. Morgan	0.28	Trace	0.04	98.93	1.07	....
Stanbridge Tp.—Lot 2, R. VIII.—D. J. Pells	1.50	Trace	0.10	95.80	1.90	....
St. Armand—Lot 21.—M. McNamara	1.60	0.24	0.02	96.16	1.75	....
Stukely Tp.—Quarry Dom. Marble Co.	5.10	1.86	1.24	62.50	28.51	....
N. Stukely, Lot 13, R. VIII	1.20	0.20	Trace	95.18	3.05	....
Brome Tp.—Lot 16, R. XI	9.88	3.86	0.70	49.10	36.07	....
Magog Tp.—Lot 12, R. XIV	10.14	0.79	4.15	50.09	35.70	....
Lime Ridge, Dominion Lime Co	1.80	0.21	0.11	96.87	1.34	....
Lime Ridge, Dominion Lime Co	0.60	0.10	0.02	98.75	0.85	....
Dudswell Tp.—Lot 21, R. VII	2.00	0.21	0.09	95.71	1.19	....
Montreal Island, Ste Genevieve	1.70	.46	.16	96.43	1.69	....
Montreal, Quarry Sovereign Lime Co	1.90	.21	.35	96.25	1.59	....
Bordeaux, Montreal Prison	2.00	.43	.11	95.18	1.90	....
Joliette, Standard Lime Co	1.00	.15	.45	97.94	.87	....
Joliette, Joseph Beaudry	.80	.30	.20	97.59	1.17	....
Joliette, Armand et Beaudry	2.00	.19	.15	96.60	1.04	....
Joliette, Nérée Gaulet	1.62	.19	.09	96.34	1.25	....
St. Elizabeth, Joliette, Ov. Farland	7.36	1.43	.65	51.78	36.91	....
St. Marc, Portneuf, Quarry Cie des Carrières	.40	.12	.04	99.14	.63	....
St. Marc, Portneuf, Damase Naud	.44	.15	.61	97.50	.54	....
Missisquoi Bay—Philipsburg	13.30	.57	1.79	48.30	34.15	....
Hull, Federal Stone Quarry	2.66	.14	.26	95.18	1.15	....
Hull, St. Louis St., Rochon Quarry	.84	.17	.33	97.52	.79	....
Oka, near monastery (Analyst C. Bousquet)	....	....	....	97.24	.71	Sulph. 0.00

The sand lime brick industry does not seem to thrive in the Province of Quebec. The plant of Brick & Tile Company at Pointe aux Trembles, has been converted into a metal foundry, for castings of brass and other alloys. The Canada Brick Company went into liquidation in November, and it is unlikely that operations will be resumed in a near future.

ELECTRIC STEEL FURNACES IN THE PROVINCE OF QUEBEC.[1]

The first patent for an electric furnace of an industrial size was applied for by the great English metallurgist Siemens, nearly three-quarters of a century after the discovery, by Davy, of the principle of the electric furnace. Four years later, in 1886, Héroult produced aluminium on a commercial scale, by utilizing the heat of the electric arc. But it is only at the beginning of the twentieth century that the electric furnace was introduced into metallurgical methods and processes as an important factor. The present war has greatly stimulated the increase in the number of these furnaces, owing to the unprecedented demand for special steels.

It may be mentioned, as a measure of the development of electro-siderurgical methods, that on January 1st, 1917, there were 471 electric furnaces in operation in various parts of the world, whereas in July, 1913, the corresponding number was only 140. In the United States the progress was most marked, as the number passed from 19 to 136 during this period. In Canada the number has increased more than six times, there being now 19 electric steel furnaces in operation.[2]

In the Province of Quebec, the first electric furnace for the commercial production of steel,was installed by the Canadian Brake Shoe Co., of Sherbrooke. This was in 1912. On January 1st, 1917 there were ten furnaces in operation in the province and four under construction. The war contracts awarded by the British Government, the aid and the guarantees given by the Imperial Munitions Board have done much towards this development. In 1916, three companies, the Canada Cement Company, Canadian Brake Shoe, and Thos. Davidson, erected electric steel furnaces in connection with the manufacture of shells. Armstrong Whitworth of Canada, installed a Héroult furnace for the production of special tool steels.

These furnaces are charged with scrap steel, such as defective shells, lathe turnings. No steel is made direct from iron ores. It may be here mentioned that Sweden produces pig-iron on a commercial scale in electric shaft furnaces.

"Electric steel is more homogenous, does not contain in-

[1]Notes by A. O. Dufresne, Mines Branch, Quebec. (Translated from the French.)

[2]The Iron Age. p. 105, Jan. 4th, 1917.

clusions and can be forged with less danger of development of a coarse crystalline structure." (Génie Civil. Vol. LXIX No. 24).

It therefore follows that for steels where the quality is the important requisite, the electric furnace is particularly suited. It takes up little room and the cost of installation is not high. If electric power can be obtained at reasonable rates, it can be operated at costs to compete with fuel furnaces. In Turin, Italy, electric furnaces are run with the power available outside of the hours of maximum load.

The electric furnace has a wide application apart from its use in the iron and steel industry. It is used in the production of aluminium, magnesium, calcium, silicon, phosphorus, zinc oxide, calcium carbide, carborundum, artificial graphite, and in the manufacture of the various ferro-alloys.

The first electric furnace used for the manufacture of commercial products in Canada, was that of the Electric Reduction Company, of Buckingham, successors to Messrs. Williams & Gibbs, who have been manufacturing ferros and phosphorus since 1896.

In 1902, at Shawinigan, on the St. Maurice River, the Northern Aluminium Co. began to produce the metal aluminium, using foreign bauxites imported from France and United States, as well as from Germany before the war. In 1907, this plant was reported to produce 25 tons of metal a day. (Mining and Metallurgical Industries of Canada, Department of Mines, Ottawa). We can get an idea of the importance of this industry, from the figures of export and imports. According to the Customs report for 1916, during that year the exports of aluminium from Canada amounted to 9,212 tons. This is apart from the home consumption. According to the report of the Shawinigan Water and Power Co. for 1914, this plant utilizes about 50,000 H.P.

The Shawinigan Water & Power Co. controls several subsidiary companies grouped in the vicinity of their large hydro-electric power plant. The oldest of these is the Canada Carbide Co. formerly the Shawinigan Carbide Co., Ltd., incorporated in 1902. This company, from small beginnings, has developed to a production of 14,000 tons of calcium carbide a year. The limestone used in the manufacture of this product comes from quarries at Stanbridge, P.Q.

The work pursued in the research laboratories of the company has led to the organization of new industries, as subsidiaries companies. We note: The *Shawinigan Electro-Metals, Ltd*, who manufacture metallic magnesium at the rate of ten tons a month.[3] As the consumption of electrodes in the electric furnaces is an important item, the *Canadian Electrode Company* was organized to manufacture them. In addition, early in 1916, The *Canadian Electro Products Co.* was organized for the manufacture of certain chemicals required for war purposes.

A description of the various thermo-electric apparatus and furnaces used in these plants would be interesting, but the policy of the companies does not allow their processes and methods to be widely known. We will therefore only give a short description of the electric furnaces used for the production of steel.

Canadian Brake Shoe Company, Sherbrooke.

This company was the first one to install an electric furnace in the Province of Quebec for the production of steel. It was started in 1912. This first furnace consists of a cylindrical steel plate shell, 64 inches in diameter and 46 inches high, enclosing a lining of magnesite brick, 14 inches thick. The electrodes are four inches in diameter.

Since then, the company has put up three additional furnaces of a capacity of three tons each. These are rectangular in shape, measuring, outside, 100 inches by 64, and inside, between the lining walls, 36 inches by 70. The hearth, 18 inches thick, is made of broken magnesite brick, held together by a tar bond, and covered with a layer of powdered dolomite, imported from Natural Bridge, N.Y. and costing $25.00 a ton. The magnesite lining is carried up above the slag line to the arched roof which is made of silica brick. The power is supplied by the Sherbrooke Hydro-Electric plant, at 6,600 volts. This is stepped down to 70 volts at the foundry. The power is taken by copper bands two inches wide, to the three graphite electrodes, set up along the length of the furnace, and held up by bracket supports. They are six inches in diameter and 48 inches in length; they are fitted with screw ends and the old ones are screwed on to the new ones; they are spaced 10 inches apart, from centers. They are raised by hand, by means of a drum, with a small steel cable. The cooling is done by three quarter inch water coils, surrounding the electrodes near the

[3]Montreal Financial Times.

roof. There is a switchboard for each furnace, with the usual gauges and meters. Also a 500 kilowatt transformer. The charge is of scrap steel, made up of lathe turnings, steel fragments, etc. For the carbon contents a certain quantity of pig iron, and coke or coal, is added. The fluxes employed are limestone, lime and fluorite. Each furnace can run five or six casts of 2½ to 3 tons every 24 hours, or an average, 15 tons of steel at a power consumption of 750 K.W. H. per ton. When the refining is done, the molten metal is tapped by tilting the furnace. The molten steel is cast into moulds, for castings of all sorts, varying in weight from six ounces to two tons. Ingots are also cast for the manufacture of 4.5 inch shells. Occasionally chrome steel castings are made.

The consumption of electrodes is on average 30 lbs. per ton of steel produced. The cost of power at Sherbrooke, is probably the lowest obtainable in the Province, at the rate of half a cent a kilowatt hour. Labour during the winter of 1916-1917 was 25 cents an hour on the average. The consumption of refractory materials was $2.60 and of electrodes $2.70 per ton of steel produced.

An average analysis of electric steel produced by the Canadian Brake Shoe Co., gave:

Sulphur	0.028	Silicon	0.25
Phosphorus	0.037	Manganese	0.15
Carbon	0.30		

It is the intention to fit the furnaces with automatic regulators for the electrodes. Moreover, orders have been placed for a Snyder electric furnace, of a 30-ton capacity per 24 hours, which will be in operation in the summer of 1917.

Armstrong Whitworth Company of Canada, Ltd.

This company has established a large, modern metallurgical plant and machine shops at Longueuil on the left bank of the St. Lawrence river, opposite the city of Montreal. Besides a complete plant for the manufacture of crucible steel, this plant, through the American Bridge Company, of Pencoyd, Pa., has set up a Héroult electric furnace of the latest type, of three ton capacity, patented by the United States Steel Corporation. The furnace is cylindrical in shape, nine feet in diameter. The shell is of thick steel plate. the hearth consists of a bed of dead burned magnesite and the sides, 15 inches thick, are made of magnesite brick. The roof is of silica brick; the life of this lining is about three weeks. The magnesite is prepared by the Basic Refractories Co. and is almost altogether Grecian material. The heat is produced by a three phase current, 60 cycles, automatic control by the special Héroult regulating apparatus. The electric current is delivered by three electrodes which are made indifferently of carbon or graphite. The electrodes are set through the roof by openings forming an equilateral triangle. They are fourteen inches in diameter, six feet long, with screw joints, and are cooled by water circulation. Their distance from the molten charge is maintained by a Héroult regulator. The electric arcs between the electrodes are produced by a current of 110 volts, 4,000 amperes. The average power consumption is 600 K.W. hours per ton of steel produced. The current is supplied by the Montreal Light, Heat and Power Company.

Besides being used for the manufacture of ferro alloys, this furnace is employed for the manufacture of special steels and high speed steels. The charge consists of scrap steel, pig iron, lime, fluorite and sand, put in by hand. The melting and refining operation takes four hours, that is to say six runs can be made in 24 hours.

The steel is cast into ingots in iron moulds. The tapping is done by tilting the furnace forward, by an electric motor of 24 H.P. This furnace is in operation since March, 1916. Three men are sufficient to operate it.

The company has lately completed an extension to its plant in which two Héroult electric furnaces of six tons each will be installed.

Besides the casting shops, the rolling mill and the forging shop, this plant includes a machine shop for the finishing of lathe tools.

The Thos. Davidson Mfg. Co. of Montreal

Under the management of Mr. C. F. Pascoe, this company has erected an electric furnace of 1½ ton, built by the Snyder Electric Furnace Co. of Chicago. The first run was made in March 1916. The furnace is cylindrical in shape, with a concave bottom and a cover which is almost flat. It is six feet in diameter and on each side are two circular doors of fourteen inches. In front is the taphole, out of which comes the molten charge by tilting the furnace, with an electric motor. The current is brought by copper cables, placed underground. These come up alongside the furnace, in a well insulated metallic box, then follow a bracket and are connected to a copper ring which circles the electrode and which is attached to the bracket. This furnace has one electrode only and a one phase current is used. After having passed through the charge, the current returns by a metallic conductor fixed under the hearth. The electrode is a carbon one, four inches in diameter and forty inches long.

The steel shell of the furnace is protected by an interior lining 15 inches thick, rich in silica. The hearth is 18 inches thick and the roof of silica brick, is 15 inches. An asbestos sheet 2 inches thick has been placed between the shell and the lining to prevent loss of heat by radiation. The lining has given excellent results, for so far, it has stood the action of 1,000 runs. The roof is less resistant and has to be replaced at the end of 200 melts.

This furnace gives 8 or 9 runs in 24 hours and the power consumption is about 600 K.W.H. per ton of steel produced. The charge is almost entirely scrap steel from the shops of the company or purchased from surrounding plants. A small quantity of pig iron is added, as well as scales of iron oxide, Fe_3O_4, resulting from rolling and forging operations. The charge is made up as follows:—crop-heads from ingots 40%; steel turnings 15 to 20%; bundles of soft steel scrap 5 to 15% (carbon 0.1%, sulphur 0.05, phosphorus 0.05, manganese 0.4); defective shells 25 to 35%; grey pig iron 1 to 2% ($3\frac{1}{2}$ to $4\frac{1}{2}$% carbon). When the operation is finished, the furnace is tilted and the metal is tapped into a travelling ladle, which hangs from an overhead rail.

The ladle is taken to a turn table on which are placed the ingot moulds for the 4.5 shells.

Analysis of the steel produced: carbon 0.44%, phosphorus 0.041%; sulphur 0.040%; manganese 0.65%; silicon 0.20% to 0.30%

Cost Per Ton of Steel Produced

Scrap steel	$19.97
Power, 600 K.W.H. at 1.41 cts.	8.64
Refractories for lining	1.00
Electrodes	0.60
Ladle	0.50
Labour	5.00
Cost of the ton of steel in the ladle	$35.71

Of this 36% is scrapped and is returned into subsequent melts, which brings the cost of the utilized steel to $55.48 less value of scrap steel from the cost ($8.56), or $46.92.

The shift comprises a melter at 40 cents an hour, two helpers at 30 cents an hour, a ladle man, and occasionally labourers for handling the scrap. The company is satisfied with the results and is in negotiation for the construction of four other furnaces of 5 tons each. They will be set up in an extension of the plant.

Canada Cement Company

Until 1915, the activities of this company were exclusively restricted to the manufacture of Portland cement. But in that year it was awarded an important contract for large shells, and immediately put up on its property at Pointe-aux-Trembles, near Montreal, a large steel framed building for melting furnaces, reheating pits, hydraulic moulding and gauging presses, and the necessary machine shops. A large proportion of the shells are manufactured from steel blooms, of rectangular section, eight inches square, and the balance is made from steel ingots cast from steel scrap melted in electric furnaces.

The melting room comprises four electric furnaces of the Héroult type, of six ton capacity each. They are rectangular in shape, and the outside dimensions are 13 ft. 6 in. x 8 ft. 6 in., and seven feet high. The shell is of steel plates, the lining of the sides is of magnesite brick and the hearth is granular magnesite. The roof arch is silica-brick. The thickness of the side lining is 12 inches, and the roof 9 inches. The heat is produced by a three-phase current giving electric arcs between three graphite electrodes, aligned along the medial line of the furnace. These electrodes are 10 inches in diameter and are made in lengths of 40 inches which can be joined together by screw threads into any length desired. They are supported by a bracket, regulated automatically, and cooled by a current of water. The power is brought to the electrodes under a voltage of 110, by twelve cables. The furnaces are charged mechanically by a travelling apparatus which brings the scrap steel. This scrap consists of 60% turnings and 40% of old steel castings. Sometimes a little "lake ore" is added. The fluxing materials are lime and fluor spar. Each furnace can yield four or five casts per 24 hours, but they do not often run simultaneously. As a rule three are in operation while the fourth is being overhauled . When the operation is finished, the tapping is done by tilting the furnace. The molten metal issues by a tap-hole placed opposite the charging opening. The tilting is done by means of a 30 H.P. motor placed under the furnace. The metal is tapped into a 10 ton ladle. A travelling crane carries it to the casting room, where it is poured into the ingot moulds for the 9.2 shells.

The power is supplied by the Montreal Light, Heat and Power Co. All the gauges and meters are on a switch board fixed to the wall of the building, 15 feet above the charging floor. The switch board is reached by a metallic stairway and gallery.

The furnaces are in operation since May, 1916. One of the great advantages of these furnaces is the ease with which the chemical control can be exercised. But as the price of power is high, the Canada Cement Company has ordered two 15 ton cupola furnaces, using gas as fuel, which are at present being erected. The gas will be supplied by gas-producers. The steel scrap and the pig iron will be melted in these furnaces and the molten metal run into the electric furnaces for the steel making.

For the iron and steel industry, the electric furnace possesses notable advantages over other furnaces as regards the quality of the steel produced and the space required for the installation, but its economic use depends on one important factor: the cost of power at the plant. This brings out the reason of the great interest devoted to the subject of electric smelting and refining of metals in Norway and other European countries, where electric power is obtainable at the following rates: Rjukan $5 per K.W. a year; Meraker, $8; Trollhattan, Sweden, $9 to $12; Livet France, $13; La Praz, France, $16.[1]

It is rather difficult to obtain rates charged for power in the Niagara district, which is a very important centre of electro-metallurgical and chemical industries. It may be mentioned however that, according to a report published by the Canadian Water Power Branch, Ottawa, the Ontario Hydro-Electric Commission, entered into a 30 year contract in 1907, with the Ontario Power Company, whereby the Commission was to be supplied with 100,000 H.P. at 12,000 volts, at a minimum price of $9 per H.P. year.

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[1]The Electric Furnace in Metallurgical Work.—U.S. Bureau of Mines, Bulletin No. 77.

From reliable sources, we are advised that in the immediate district of Three Rivers, blocks of power of 10,000 to 30,000 H.P. can be obtained at the rate of $15 per H.P. year for alternating current, 60 cycles at any required voltage. At Shawinigan and at Grand Mère, it is probable that slightly better rates could be obtained.

Moreover, it may be mentioned that the project of development of the Grande Décharge, the outlet of Lake St. John, is under way and it is expected that blocks of power, from this source, will be available at less than $10 a H.P. year, taken at the switch board.

In the district of Quebec electric power for manufacturing purposes, is obtainable even is small quantities, at the rate of one cent per K.W. hour, in addition to a fixed rate of $1 per H.P. year. When factories which are near power-houses, can restrict their power consumption to the time of the day outside of the hours of maximum load, extremely favourable terms can be obtained.

Another important factor in the economic operation of electric furnaces and in the costs of production, is the distance from which the raw materials have to be brought to the furnace, and the cost of delivering the finished product to the consumer. In some cases the cost of transportation more than offsets the cheaper cost of power.

LIST OF THE

Principal Operators and Owners of Mines and Quarries

IN THE PROVINCE OF QUEBEC

ASBESTOS

Asbestos Corporation of Canada Limited,
J. McCallum, Secretary, 263 St. James Street, Montreal.

Bell Asbestos Mines,
Hon. Geo. R. Smith, Vice-Pres. and Mgr., Thetford Mines, Que.

Bennett & Martin Chrome Mines,
Coleraine, Que.

Black Lake Asbestos & Chrome Co., Limited,
J. E. Murphy, Mgr., Black Lake, Que.

Eastern Townships Asbestos Co.,
P. Anger, Mgr., Beauceville, Que.

The Federal Asbestos Co., Limited,
J. A. C. Audet, Mgr., Robertsonville, Que.

The Frontenac Asbestos Mining Co.,
F. W. Ross, Mgr., 92 St. Peter Street, Quebec City.

Jacob Asbestos Mining Co., of Thetford, Limited,
E. J. Wilson, Mgr., Thetford Mines, Que.

Johnson's Co.,
A. S. Johnson, Mgr., Thetford Mines, Que.

Manville Asbestos Company,
Asbestos, Que.

The Martin-Bennett Asbestos Mines, Limited,
H. E. Peters, Secretary. Thetford Mines, Que.

Quebec Asbestos Corporation,
E. E. Spafford, Mgr., East Broughton, Que.

Windsor Asbestos Company Limited,
Tecumseh, Ont.

CHROME

P. E. Beaudoin,
Thetford Mines, Que

J. V. Belanger,
Black Lake, Que.

Bennett & Martin Chrome Mines,
Fred. Bennett, Manager, Thetford Mines, Que.

Black Lake Asbestos & Chrome Co., Limited,
J. E. Murphy, Manager, Black Lake, Que.

Coleraine Chromium Limited,
c/o Antonin Lesage, Les Prevoyants du Canada, Quebec City.

Dominion Mines & Quarries Limited,
Dominion Bank Building, Toronto, Ont.

The Fletcher Pulp & Lumber Co., Limited,
H. Bruce Fletcher, Secretary, Sherbrooke, Que.

Jos. M. Johnson,
Black Lake, Que.

J. D. Kennedy,
Sherbrooke, Que.

The Martin-Bennett Asbestos Mines, Co.,
H. E. Peters, Secretary, Thetford Mines, Que.

Mutual Chemical Company of Canada, Limited,
Black Lake, Que.

Douglas B. Sterrett,
St. Cyr, Richmond County, Que.

Jos. A. Thompson,
Black Lake, Que.

David Wilson,
Sherbrooke, Que.

W. J. Woolsey,
Thetford Mines, Que.

COPPER

Campbell & Forbes Syndicate,
319 Coristine Building, Montreal, Que.

Eustis Mining Company,
F. M. Passow, Mgr., Eustis, Que.

La Mine d'Or et Cuivre,
c/o P. E. Beaudoin, Thetford Mines, Que.

A. O. Norton,
W. Jenkins, Manager, Coaticook, Que.

N. S. Parker,
Eastman, Que.

Auguste Renault,
Ville Marie, Que.

Pierre Tétreault,
416 Power Building, Montreal.

Weedon Mining Co., Limited,
L. D. Adams, Pres., 609 Eastern Townships Bank Bldg., Montreal.

FELDSPAR

S. Carsley & Co.,
151 Notre Dame St. W., Montreal.

The Dominion Mining Syndicate,
c/o O'Brien & Fowler, Bush Winning, Mgr., Beech & Preston Sts., Ottawa,

Eureka Flint & Spar Co.,
Trenton, N.J.

O'Brien & Fowler,
Bush Winning, Mgr., Beech & Preston Sts., Ottawa.

GOLD

Champs d'Or Rigaud-Vaudreuil,
Room 425, Transportation Bldg., Montreal.

Eustis Mining Co.,
F. M. Passow, Mgr., Eustis, Que

J. F. Stabell & Co.,
1127 Niagara St., Buffalo, U.S.A.

Weedon Mining Co.,
L. D. Adams, Mgr., 609 Eastern Township Bank Bldg., Montreal.

Zinc Company Limited,
Room 605, Eastern Townships Bank Bldg., Montreal.

GLASS SAND

O. G. Brunelle,
Cascades Point, Que.

Dominion Glass Co., Limited,
Royal Trust Bldg., Montreal.

GRAPHITE

Bell Graphite Co., Limited,
Box 185, Buckingham, Que.

The Canadian Graphite Co.,
T. W. P. Patterson, Mgr., Room 34, Coristine Bldg., Montreal.

Multipar Syndicate, Limited,
London, England.

New Quebec Graphite Co., Limited,
R. C. Rowe & C. N. Daly, Mgrs., Buckingham, Que.

Peerless Graphite Co.,
53 Rugby ave., Rochester, N.Y.

Plumbago Syndicate,
Excelsior Life Bldg., Toronto.

IRON & TITANIC IRON

American Titanic Iron Co.,
c/o Hon. S. N. Parent, Parliament Bldg., Quebec City.

Baie St. Paul Titanic Iron Ore Mining Export Co.,
J. O. Paré, Mgr., Baie St. Paul, Charlevoix Co., Que.

The Canada Iron Corporation, Limited,
Mark Fisher Bldg., Montreal.

General Sir John Carson,
18 Royal Insurance Bldg., Montreal.

Manitou Iron Mining Co.,
Jos. E. Globensky, 364 University St., Montreal.

KAOLIN

Canadian China Clay Co. Limited,
Room 521, Transportation Bldg., Montreal.

St. Remi Kaolin Co.,
Campbell Bldg., Elmira St., Montreal.

MAGNESITE

Canadian Carbonate Co., Limited,
J. R. Colby, Montreal.

Dominion Magnesite Co.,
Calumet, Que.

Fitzsimons & Boshart,
139 Bay St., Ottawa.

International Magnesite Co.,
708 Eastern Townships Bank Bldg., Montreal.

A. R. Lanigan,
Calumet, Que.

North American Magnesite Co.,
Room 301, 180 St. James St., Montreal.

N. S. Parker,
Eastman, Que.

Scottish-Canadian Magnesite Co., Reg'd.,
211 McGill St., Montreal.

MICA

William Argall,
Laurel, Argenteuil Co., Que.

Beaver Mica Mfg., Co., Limited,
124 Rideau St., Ottawa, Ont.

Blackburn Brothers,
H. L. Forbes, Manager, 212 Creighton Street, Ottawa.

Brown Brothers,
Cantley, Que.

Calumet Mica Co.,
3 Clarence St., Ottawa.

Capital Mica Co., Limited,
W. Ahearn, Manager, St. Pierre de Wakefield, Que.

Chabot & Co.,
124 Rideau St., Ottawa.

J. A. Chenevert,
c/o Le Courrier, Sorel, Que.

La Compagnie Minière de Mica Blanc,
1 Beaver Hall Hill, Montreal.

William Cleland,
Bouchette, Wright Co., Que.

Cross & Wilson,
Cascades, Hull, Que.

Joshua Ellard,
Wright, Que.

H. T. Flynn,
106 Montcalm Street, Hull, Que.

J. B. Gauthier,
Box 226, Buckingham, Que.

J. B. Gorman,
Box 166, Buckingham, Que.

Laurentide Mica Co., Limited,
corner Bridge and Queen Streets, Ottawa.

The Loughborough Mining Co.,
N. J. Sproule, Mgr., c/o G. W. McNaughton, Sydenham, Ont.

Adelard Morin,
Val des Bois, Labelle Co., Que.

O'Brien & Fowler,
Bush Winning, Mgr., Beech and Preston Sts., Ottawa.

W. L. Parker,
Buckingham, Labelle Co., Que.

Vavasour Mining Association,
22 Metcalfe Street, Ottawa, Ont.

Wallingford Bros.,
Banque Nationale Bldg., Ottawa, Ont.

Wallingford Mica & Mining Co.,
Perkins, Que.

Watts & Noble,
Perkins Mills, Que.

Webster & Co.,
274 Stewart Street, Ottawa, Ont.

MINERAL WATER

Abenakis Mineral Spring Co., Limited,
W. E. Watt, Manager, Abenakis Springs, Que.

Alfred Ferland,
1661 rue Bordeaux, Montreal.

Gurd & Co., Limited,
74 Bleury Street, Montreal, Que.

Lyall Trenholm & MacDonall,
Montreal West, Que.

Radnor Water Co.,
Geo. C. Kemp, Manager, Mark Fisher Building, Montreal, Que.

Ratté & Frères,
22 rue Bigaouette, Quebec City.

Cyprien Roy,
St. Germain, Kamouraska, Co., Que.

La Société des Eaux Naturelles du Canada,
Trois Rivières, Que.

St. Léon Mineral Water Co.,
R. W. Nebb, Mgr., Toronto St., Toronto, Ont.

M. Timmons & Son,
Côte d'Abraham, Quebec City.

Veillet & Frère,
Ste. Geneviève, Batiscan Co., Que.

MOLYBDENITE

Aldfield Mineral Syndicate,
667 Echo Drive, Ottawa, Ont.

The Canadian Wood Molybdenite Co.,
14 Metcalfe St., Ottawa, Ont.

General Sir John Carson,
18 Royal Insurance Bldg., Montreal.

Chabot & Co.,
124 Rideau St., Ottawa, Ont.

Geo. A Dion,
La Sarre, Temiscaming, Que.

M. L. Foley,
12 Maynard ave., Toronto.

The Height of Land Mining Co.,
S. P. Wilson, Mgr., 316 St. James St., Montreal.

T. E. Richardson,
Portage-du-Fort, Que.

The St. Maurice Mines Co., Limited,
c/o A. E. Doucet, Quebec City.

NATURAL GAS

The Canadian Natural Gas Co.,
P.O. Box 2072, Montreal.

The National Gas Co., of Canada,
c/o Mr. E. B. Devlin, Hull, Que.

OCHRE

Thos. H. Argall,
P.O. Box No. 2, Three Rivers, Que.

Canada Paint Co., Limited,
Jos. Bradley, Manager, Red Mill, Que.

Champlain Oxide Co.,
Lucien Carignan, Manager, Three Rivers, Que.

P. Jobidon,
12 rue Ste. Famille, Quebec City.

François Ouellet,
Ste-Gertrude, Nicolet Co., Que.

PEAT

Peat Industries Limited,
Imperial Bank Chambers, Montreal.

PHOSPHATE

Blackburn Bros.,
H. L. Forbes, Manager, 134 Wellington St., Ottawa.

F. Burgoyne,
Buckingham, Que.

J. G. Higginson,
Buckingham, Que.

O'Brien & Fowler,
Bush Winning, Manager, Beech and Preston Sts., Ottawa

W. Gowan,
Poltimore, Que.

Papineau Lumber Co., Limited,
H. T. Tétreau, Manager, Papineauville, Co. Labelle, P.Q.

D. Vallier,
Buckingham, Que.

Wallingford Mica & Mining Co.,
Banque Nationale Bldg., Ottawa.

Edward Watts,
19 Chestnut Park, Toronto, Ont.

QUARTZ

Canadian China Clay Co.,
99 St. James St., Montreal.

J. McClements,
Buckingham, Que.

L. Couture,
Buckingham, Que.

J. Stewart,
Buckingham, Que.

G. Pudenaud,
Buckingham, Que.

M. Rowan,
Buckingham, Que.

J. Bigelow,
Buckingham, Que.

SILVER

Eustis Mining Co., Limited,
F. M. Passow, Manager, Eustis, Que.

Weedon Mining Company,
L. D. Adams, President, Weedon, Que.

Zinc Company, Limited,
Room 605, Eastern Townships Bldg., Montreal.

TALC

J. N. Martel,
Belmina, Wolfe Co., Que.

Geo. R. Pibus,
Knowlton, Que.

ZINC AND LEAD

The Calumet Zinc & Lead Co.,
Jas. W. Hennessey, Fort Coulonge, Que.

The Laurentide Mining Co.,
Notre Dame des Anges, Portneuf Co., Que.

Messrs. Lyall, Maher & Beidelman,
Grande Cascapedia, Que.

Montauban Mining Syndicate,
N. Thibault, Notre Dame des Anges, Portneuf Co., Que.

The New Richmond Mining Co.,
New Richmond, Que.

North American Mining Co.,
New Carlisle, Que.

Pierre Tetreault,
Room 416, Power Bldg., Montreal.

N. T. Turgeon & J. A. A. Bedard,
Quebec Ry. Bldg., Quebec City.

Zinc Company Limited,
Notre-Dame des Anges, Portneuf County, Que.

BRICK

Paul Anctil,
Rivière du Loup, Que.

N. L. Auger,
Ville de St. Tite, Champlain Co., Que.

W. D. Bell,
1286 rue St. Valier, Quebec City.

Narcisse Blais,
12 Marie de l'Incarnation St., Quebec City.

La Briqueterie de Rimouski Limited,
Rimouski, Que.

The Citadel Brick & Paving Block Co., Limited,
P. Galarneau, Manager, 42 Dalhousie St., Quebec City.

La Compagnie de Briques de l'Islet, Limited,
L'Islet, Que.

La Compagnie de Briques de Matane,
St. Jerome de Matane, Que.

Olivier Danville,
St. Casimir, Que.

J. B. Desroberts,
St. Jean Deschaillons, Que.

Joseph Desrochers,
Warwick, Que.

The Eastern Townships Brick & Mfg., Co.,
Lennoxville, Que.

David F. Hodgins,
Box 87, Shawville, Que.

Lafontaine & Martel,
St. Tite, Champlain Co., Que.

Evang. Laliberté,
St. Jean Deschaillons, Que.

Stanislas Laliberté,
St. Jean Deschaillons, Que.

Edmond Lapointe,
Acton Vale, Bagot Co., Que.

Trefflé Leclerc,
Ste. Anne des Plaines, Que.

Michel Mathieu,
Sorel, Richelieu Co., Que.

Alex. Mills,
Ormstown, Chateauguay Co., Que.

National Brick Co. of Laprairie, Limited,
10 Victoria Square, Montreal.

Elie Paradis,
St. Raymond, Portneuf Co., Que.

Paradis & Létourneau,
Stadacona, Quebec City.

Ulderic Paris,
St. Jean Deschaillons, Que.

Philippe Potvin,
St. Jean Deschaillons, Que.

Proulx Brothers,
Richmond, Que.

D. Rouleau & Fils,
Ville St. Tite, Champlain Co., Que.

The Sherbrooke Tile & Brick Co.,
Record Block, Sherbrooke, Que.

The St. Lawrence Brick Co., Limited,
71 St. James Street, Montreal, Que.

Emile Théroux,
Mitchell Station, Que.

Edmond Tondreau,
St. Eugène de Lamartine, L'Islet, Que.

CEMENT

Canada Cement Co., Limited,
F. P. Jones, Manager, Herald Building, Montreal.

GRANITE

The B. & L. Granite Co., Limited,
20 St. James St., Montreal.

Auguste Bernier,
Roberval, Que.

James Brodie,
Graniteville, Que.

James Brodie & Son,
128 Bleury Street, Montreal.

La Compagnie de Granit de Mégantic, Limitée,
Lac Mégantic, Que.

M. P. & J. T. Davis,
14 St. Peter St., Quebec City.

Augustin Delisle,
Rivière à Pierre, Que.

Alex. Doyer,
Rivière à Pierre, Que.

Dumas & Frère,
Rivière à Pierre, Que.

William Duncan,
Graniteville, Que.

John Dupras,
Marion, Labelle Co., Que.

The Laurentian Granite Co., Limited,
Room 82, 224 St. James St., Montreal.

National Battlefields Commission,
2 Cook St., Quebec City.

S. B. Norton,
Beebe Jct., Stanstead Co., Que.

Jos. Perron,
Rivière à Pierre, Que.

R. A. Rideker,
Graniteville, Que.

Stanstead Granite Quarries Co., Limited,
Beebe Jct., Stanstead Co., Que.

William Thompson,
Beebe Plain, Que.

Fortunat Voyer & Frères,
Rivière à Pierre, Que.

LIME

Arnaud & Beaudry,
Joliette, Que.

Benoit & Fils,
St. Dominique de Bagot, Que.

Arthur Boivin,
Pont Rouge, Portneuf Co., Que.

F. D. Brigham,
85 Duke St., Ottawa.

R. B. Carswell,
Bryson, Que.

Gaspard Desfonds,
St. Cuthbert, Que.

Achille Desilets,
St. Louis de Champlain, Que.

Dominion Lime Co.,
Sherbrooke, Que.

Lucien Doucet,
St. Louis de Champlain, Que.

C. A. Gervais,
1460 Cadieux St., Montreal.

Emery Héon,
St. Louis de Champlain, Que.

Octave Héon,
St. Louis de Champlain, Que.

Ephrem Lavallée,
La Chaloupe, Joliette Co., Que.

Johnny Lefebvre,
St. Louis de Champlain, Que.

Olivier Limoges,
477 Papineau Ave., Montreal.

Z. O. Limoges,
40 Poupart St., Montreal.

Missisquoi Marbles Limited,
Philipsburg, Missisquoi Co., Que.

Thos. McCambly,
Kazubazua, Que.

Montreal Lime Co.,
31 Prenoveau St., Montreal.

Placide Sanche,
Côte St. Louis, Ste. Thérèse, Terrebonne Co., Que.

Sovereign Lime Company Limited,
Delorimier Ave. & C. P. R. Tracks, Montreal.

Standard Lime Co., Limited,
St. Paul, Joliette Co., Que.

Wright & Co., Inc.,
267 O'Connor St., Hull, Que..

LIMESTONE

Adolphe Barron,
La Carrière, Bagot Co., Que.

Jos. P. Beaudry,
Joliette, Que.

Dr. P. Bertrand,
Shawinigan Falls, Que.

Bessette & Gagnon,
P.O. Box 428, St. John's, Que.

Canada Carbide Company, Limited,
Power Bldg., Montreal.

Canada Iron Foundries Limited,
Imperial Bank Bldg., Montreal.

Carriere de Quebec, Limitée,
Quebec Ry. Bldg., Quebec City.

Joseph Charbonneau,
3020 rue St. Hubert, Montreal.

Chateau Richer Quarry Co.,
Sault a la Puce, Montmorency, Que.

Chateauvert Quarry Co., Reg'd,
52 St. Paul Street, Quebec City.

La Cie de Briques de Québec, Limitée,
Beauport, Que.

La Cie des Carrières,
St. Marc des Carrières, Que.

La Compagnie de Construction Durocher, Limitée,
Montreal Est., Que.

Alfred Cossette,
Valleyfield, Que.

Albert Cousineau,
288 rue de Gaspé, Montreal.

The L. Deguire Quarry Co.,
St. Laurent, near Montreal, Que.

The DeLorimier Quarry Co.,
1952 Iberville St., Montreal.

Frank Deraiche,
Chandler, Gaspé.

Deschambault Quarry Corporation,
52 St. Paul St., Quebec City.

The Deschambault Stone Co., Limited,
St. Marc des Carrières, Que.

Pite Desroches,
Joliette, Que.

R. C. Dickson,
601 Monsabré, Montreal.

East End Quarry,
2753 Dandurand St., Montreal.

The Federal Stone & Supply Co., Limited,
213 Sussex St., Ottawa.

Martin Gagnon & Frères,
3363 Lajeunesse St., Montreal.

General Contracting Co., Limited,
357 Kensington, Montreal.

Joseph Gravel,
1551 Chambord St., Montreal.

Institution des Sourds-Muets,
1941 St. Dominique St., Montreal.

Jackson Bros.,
Grondines, Portneuf Co., Que.

Kennedy Construction Co., Limited,
704 Shaughnessy Bldg., Montreal.

J. O. Labelle & Co.,
1792 Côte des Neiges, Montreal.

The Félix Labelle Quarry Co., Limited,
St. François de Sales, Que.

Elz. Laforce,
St. Marc des Carrières, Que.

Joseph Lapointe,
Cartierville, Que.

Laurentian Stone Co., Limited,
53 rue Albert, Hull.

Laurin & Leitch,
5 Beaver Hall Sq., Montreal.

Mrs. J. H. Leahy,
120b Stadacona Street, Montreal.

Victor Lecrenier,
2066 Cartier St., Montreal.

Leduc & de Repentigny,
St. Timothée, Beauharnois, Que.

Narcisse Lord,
St. Jean, Que.

Maisonneuve Quarry Co., Limited,
2855 Boulevard, Rosemount, Montreal.

O. Martineau & Fils, Limited,
371 Marie Anne Ave., Montreal.

Montreal Concrete Works Co., Limited,
413 Power Bldg., Montreal.

Damase Naud,
St. Marc des Carrières, Que.

Damien Paquette,
Village Bélanger, Laval, Que.

Jules Petitgeau,
2041 Papineau Ave., Montreal.

Plouffe & Lagacé,
Cartierville, Que.

The W. J. Poupore & Co.,
474b Nicolet St., Montreal.

Price Bros. & Co., Limited,
Chambord, Que.

Quinlan, Robertson, Limited,
601 Bank of Toronto Bldg., Montreal.

A. Richer,
Lacarrière, Bagot, Que.

Roberge, Giroux,
Chateau Richer, Que.

Rogers & Quirk,
1701 Iberville Street, Montreal.

Theodore Saumure,
Cap St. Martin, Que.

Shawinigan Quarry & Construction Co.,
4 Hart St., Three Rivers, Que.

R. F. Smith Construction Co.,
27 Hillside St., Westmount.

The St. Laurent Quarry Co., Limited,
Cap St. Martin, Laval Co., Que.

Standard Lime Co., Limited,
St. Marc des Carrières, Que.

Stinson-Reeb Builders Supply Co., Limited,
903 Read Bldg., Montreal.

Pierre Tétreault,
416 Power Bldg., Montreal.

Villeray Quarry Co., Limited,
848 Du Rosaire Street, Montreal.

Vinet & Durand,
4631 Notre Dame St. East, Montreal.

Wright & Co., Incorporated,
267 O'Connor St., Hull, Que.

MARBLE

Missisquoi Marbles Limited,
Philipsburg, Que.

The Pontiac Marble & Lime Co., Limited,
193 Sparks St., Ottawa.

POTTERY

W. B. Bell,
1286 St. Valier St., Quebec City.

Canadian Trenton Potteries Co., Limited,
St. John's, Que.

The Citadel Brick & Paving Blocks Co., Limited,
42 Dalhousie St., Quebec.

Dominion Sanitary Pottery Co.,
189 St. James St., Montreal.

E. L. Farrar,
Iberville, Que.

Montreal Fire-Brick Works, Limited,
399 St. Ambroise St., Montreal.

Montreal Terra-Cotta Lumber Co.,
23 Board of Trade Bldg., Montreal.

Poterie Dion Enrg.,
40 Dominion Bldg., Quebec City.

Standard Clay Products Limited,
St. Johns, Que.

St. Lawrence Brick & Paving Block Co., Limited,
Dalhousie St., Quebec City.

SAND

Jean Aybram,
Ste. Emelie Jct., Joliette, Que.

Robert Boa,
Hillhead, Argenteuil Co., Que.

The Bonner Sand & Ballast Co.,
South Durham, Que.

Canadian Sand & Gravel Co.,
283 Regent Ave., Montreal.

Canadian Siegwart Beam Co., Limited,
103 St. François Xavier, Montreal.

Compagnie Sable Union Limitée,
105 Dalhousie St., Quebec City.

Dominion Sand & Stone Co., Limited,
506 Canadian Express Building, Montreal.

Francis Hankin, Co.,
201 Coristine Building, Montreal.

Imperial Sand & Gravel Co.,
Joliette, Que.

Keystone Wall Plaster Co.,
Ste. Thérèse de Blainville, Que.

Joseph Labrecque,
Lanoraie, Que.

J. L. Lachance, Limited,
Quebec City.

Arthur Letourneau,
St. Remi, Napierville, Que.

Melançon Frère,
Grand Mère, Champlain Co., Que.

Jules Miller,
300 St. Francis Street, Quebec City.

Montreal Sand & Gravel Co.,
270 Ottawa Street, Montreal.

Quebec Central Ry.,
Sherbrooke, Que.

Moise Robidoux,
Yamaska, Que.

Royal Moulding Sand & Gravel Co.,
St. Félix de Valois, Que.

The Standard Sand & Gravel Co., Limited,
P.O. Box 2652, Montreal.

Napoléon St. Louis,
Fontarabie, Maskinongé Co., Que.

The Touzin Sand Co.,
74 Common Street, Montreal.

Villeneuve & Co.,
St. Jerome, Terrebonne Co., Que.

SANDSTONE

Montreal Sand & Gravel Co., Limited,
270 rue Ottawa, Montreal.

H. T. Routhly,
Haileybury, Ont.

The Sydney Kirby Co.,
213 Sussex St., Ottawa.

SLATE

The New Rockland Slate Co.,
Room, Merchants Bank Bldg., 205 St. James St., Montreal.

STATISTICS OF ACCIDENTS

IN MINES AND QUARRIES REPORTED DURING THE YEAR 1916*

A. O. Dufresne.

Renewed activity in the mineral industry of the Province of Quebec is manifested by the number of workmen employed in mines and quarries. Owing to the great demand for labour to replace the miners who volunteered for overseas service in the Canadian army and to meet the demands of mine owners, many persons obtained work who had no idea of the methods and dangers connected with mining and quarrying. Thus in the asbestos, chrome, molybdenite, zinc, lead and other mines, a good many of the supernumerary workmen are farmers who, as soon as the principal farm work was done hired themselves for the winter season, being attracted by the high wages offered. Unfortunately, their inexperience and ignorance are a cause of accidents.

The number of men who worked for the equivalent of a year —*i.e.* 300 days—increased from 5,767, in 1915, by 14% in 1916. It was 6,601, made up as indicated in Table No. 1. It is interesting to note that there was a marked increase in the number of men employed in mines and it must be said that, for the first time in the history of the mining industry, the value of the products of the mines has exceeded that of building materials and this during the year showing the greatest aggregate production from mines and quarries.

On the other hand, by carefully examining the figures of the reported number of workmen connected with the production of building materials, a considerable increase in some cases and a no less decrease in others, will be noted. Among the items showing an increase are: cement, granite and lime, while there is a decrease for bricks, limestone, marble, slate, sandstone and sand.

The demand for men for the army, for the new industries arising from the war, and the increase in mining production, caused a rise in the wages of the workmen employed in the latter industry,

* Translated from the French.

TABLE I

Persons employed in the Mines, Quarries and Concentrating Mills in the Province of Quebec

Mines, Quarries and Mills	Number of men calculated on 300 days	
	1915	1916
Asbestos (quarries and mills)	2,251	2,705
Copper and Pyrite, Silver, Gold	299	361
Chrome, Titaniferous Ore, Zinc and Lead	203	373
Feldspar, Kaolin, (quarries, pits and mills)	25	53
Graphite, Mica, Phosphate	80	211
Magnesite	58	179
Mineral Water (springs and works)	35	11
Molybdenite	....	85
Ochre	32	57
Brick, Pottery (clay pits and mills)	524	518
Cement (quarries and mills)	332	626
Granite	106	294
Lime (quarries and kilns)	149	177
Limestone (quarries and dressing works)	1,426	775
Marble, Slate and Sandstone	146	112
Sand (pit and river)	101	64
	5,767	6,601

but to a lesser degree than in some manufacturing industries. At Thetford Mines, in January 1916, a miner earned $1.75 a day, in May the owners gave 20 cents per hour; during the month of August the miners organized a strike which lasted 24 days and brought them no increase in wages; in the middle of November, the mine managers, unanimously granted 25 cents per hour.

The aggregate amount of salaries, which was $3,419,857.00 in 1915, rose to $4,447,298.00 in 1916, being an increase of 30%.

Instead of 2,777 men employed in the production of building materials in 1915, there were only 2,574, in 1916 on account of the great falling off in quarrying limestone.

On the other hand, the number of men employed in the mineral industry rose from 2,990 to 4,035, being an increase of 35%.

In 1916, 8,263 men worked intermittently in the mines and quarries of the province for an aggregate number of 1,980,373 days. Dividing that number of days' work by 300, the number of working days in the year, we get 6,601 for the men-year. The "Man-year,"—300 days in the year on which work was done—is the basis of these statistics and all our calculations are made in accordance with it.

It should be noted here that some of the provinces of Canada do not make out their accident statistics on this basis; for their compilation they take the total number of men who have found employment in mines or the concentrators and mills connected with them during the year. Any person comparing the statistical figures of two provinces, must therefore bear in mind this difference in the compilation of the tables.

During the year 1916, the Mines Branch was notified of 199 accidents that happened during the year in mines, quarries, clay pits and sand-pits in the province, while 175 were recorded in the previous year. There were 18 fatal accidents in the past year while the statistics for 1915 gave 13. The index number of violent deaths in mines rises therefore from 2.25 to 2.72 per 1,000 men. This proportion is comparatively low. It must not be thought, however, that the number for the Province of Quebec cannot be lowered; quite the contrary. The installation of new preventive mechanical devices, closer supervision by the head men, prudence and desire to avoid the risk of being killed or injured on the part of the workmen, may very largely contribute to decreasing the number of accidents. In justice to the managers of mining establishments in the Province of Quebec it must be said that they do a great deal to add to the safety of the work of their employees.

TABLE II

Workmen in	Number	Salaries	Number of days' work	Number of men on 300 days' basis
Producing Mines.......	4,269	$2,571,500	1,192,009	3,974
Non-Producing Mines .	209	34,490	18,462	61
Totals............	4,478	$2,605,990	1,210,471	4,035

The labour expended on assessment work for retaining rights on lands leased under the provisions of the Mining Act is not included in this table.

Table III shows the number of workmen employed in mines and quarries and the number of fatal and non-fatal accidents. In that table the word "quarry" includes clay-pits and sand-pits.

TABLE III

Workmen in	Number of men on 300 days' basis	Accidents		Total	Per 1,000 employed
		Fatal	Non-fatal		
Mines	4,035	13	170	183	45.3
Quarries	2,566	5	11	16	6.2
Totals	6,601	18	181	199	30.1

TABLE IV

Accidents in Mines, Quarries and Mills of the Province of Quebec for 1916.

	Fatal		Non-fatal		Totals	
	No.	%	No.	%	No.	%
MINES:						
Underground	1	0.5	9	4.5	10	5.0
Open pits	11	5.5	124	61.5	135	67.0
Surface	0	0.0	16	9.0	16	9.0
	12	6.0	149	76.0	161	81.0
QUARRIES:						
Pits	3	1.5	4	2.0	7	3.5
Surface	1	0.5	3	1.5	4	2.0
	4	2.0	7	3.5	11	5.5
MILLS:						
Mills	2	1.0	14	7.0	16	8.0
Shops	0	0.0	9	4.5	9	4.5
Power Plants	0	0.0	2	1.0	2	1.0
	2	1.0	25	12.6	27	13.5
Totals	18	9.0	181	91.0	199	100.00

By non-fatal accident the Mines Branch of the Province of Quebec means any accident which incapacitates a man for work for a period of ten days or more but does not cause loss of life.

This year, for every 1,000 men-year employed in the mining industry in the Province of Quebec, 2.72 fatal accidents were recorded. There were five such accidents in quarries while, last year, there were only three.

In mining operations, apart from quarries, out of 4,035 men employed there were thirteen fatal accidents, being an average of 3.22 per 1,000 and a decrease from 1915 when the percentage was 3.34 per 1,000 men-year. But, while in 1915 the province had no accident to record in the concentration mills, two were reported in 1916, the details of which will be found further on.

TABLE V

Analysis of fatal accidents in the Province of Quebec, 1916.

	Underground		Open Pits		Total	
	No.	%	No.	%	No.	%
MINES:						
Rock falls and slides..	..	..	8	44.4	8	44.4
Cable-derrick.........	..	..	3	16.6	3	16.6
Gassing..............	1	5.5	..	..	1	5.5
	1	5.5	11	61.0	12	66.5
MILLS:						
Bins.................	..	..	1	5.5	1	5.5
Shafting.............	..	..	1	5.6	1	5.6
	..	..	2	11.1	2	11.1
QUARRIES:						
Boom-derrick.........	..	..	1	5.5	..	5.5
Rock Falls and Slides.	..	..	2	11.2	2	11.2
Explosives...........	..	..	1	5.5	1	5.5
	..	..	4	22.2	4	22.2
Total...........	1	5.5	11	94.3	18	99.8

TABLE VI

Analysis of non-fatal accidents in mines, quarries and mills of the Province of Quebec in 1916

	Under-ground	Open Pits	Surface	Total	
				No.	%
MINES:					
Rock falls and slides	7	52	..	59	39.6
Cable-derrick	..	40	..	40	27.5
Cars and tracks	1	3	12	16	10.6
Breaking stone	..	10	..	10	6.6
Drilling	1	6	..	7	4.6
Falls	..	5	..	5	3.3
Falls of Objects	..	3	1	4	2.6
Explosives	..	3	..	3	2.0
Miscellaneous	..	2	..	2	1.3
Boom-Derricks	..	..	2	2	1.3
Burns	..	..	1	1	0.6
	9	124	16	149	100.0

	Under-ground	Open Pits	Surface	Total	
				No.	%
QUARRIES:					
Rock falls and slides	..	1	1	2	28.6
Cars and Trucks	..	..	2	2	28.5
Explosives	..	1	..	1	14.3
Falls of objects	..	1	..	1	14.3
Falls	..	1	..	1	14.3
	..	4	3	7	100.0

	Power Plants	Concen-trators	Machine Shops	Total	
				No.	%
MILLS AND CONCENTRATORS					
Falls of objects	1	3	5	9	36.0
Machines	1	3	3	7	28.0
Falls of rocks	..	4	..	4	16.0
Belts and pulleys	..	3	..	3	12.0
Falls	..	1	1	1	4.0
Unclassified	..	..	1	1	4.0
	2	14	9	25	100.0

TABLE VII

THE AGE OF THE INJURED, 1916

	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	Un-known	Total
Non-Fatal...	19	32	28	19	12	8	15	15	6	3	24	181
Fatal.......	2	3	2	3	2	0	2	1	..	..	3	18
Total.....	21	35	30	22	14	8	17	16	6	3	27	199

TABLE VIII

Falls of Rock by Month, 1916

Non-Fatal	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Underground	......	1	1	2	1	......	1	1	......	......	......	0	7
Open Pits	2	9	10	7	1	6	2	5	5	1	2	2	52
Quarries	......	......	......	......	......	......	......	......	1	......	......	1	2
Fatal													
Underground	......	......	......	......	......	......	......	......	......	......	......	......	....
Open Pits	......	......	2	......	3	......	....	1	......	1	1	......	8
Quarries	......	......	......	......	......	......	......	......	1	......	1	......	2
Total	2	10	13	9	5	6	3	7	7	2	4	3	71

Rock slides:—

As may be seen by the foregoing tables, rock slides are the chief cause of accidents in mines and quarries. Nearly one-half of the accidents are due to them.

By studying the list of accidents, it will be seen that most rock slides take place when the men are working at the foot of a slope or of a pile. The shovellers working these, through ignorance, imprudence, or a desire to get through their work more quickly, scoop out the under part until a slide takes place. As a rule the workman does not pay sufficient attention to the working-face because he is busy with his own work, a rock-slide occurs and he is struck before he has time to see where the rock will fall. And, even if he knew the exact moment when the rock falls, there may be obstacles in the way and he cannot escape. Then a toe, a foot, or a leg may be crushed and sometimes a fatal accident will result. Frequently, at the foot of rock-slides a short distance away, there may be heaps of large blocks of stone taken out of the pile with the intention of bull-dozing them with dynamite. Or again derrick boxes may be in the way especially when large ones are used. The few seconds to be taken in getting around them in running away, are too often fatal. The attention of mine managers must be called to such accidents and a little investigation on their part will enable an adequate means of protecting the workmen to be found.

In more than one pit or open-working, the many blasts fired at the same time cause considerable masses of loose stone to be formed. When the pit slope is too steep, workmen are sometimes sent to certain points to start the stone rolling down. Through recklessness of danger, or undue confidence in the security of their position, men work almost beneath the mass to be rolled down, and accidents occur thereby. Again, the piece of rock to be sent down acts as a key for a whole mass of stone lying above it and the workman, through ignorance or recklessness works so well that not only will the stone he is trying to loosen, fall down, but a whole slice of the mass will be carried down also.

This year we have had to record several accidents of this kind, some of which were fatal. It should be noted here that the number of accidents from rock-slides is greater where the faces are high in deeper pits. Therefore it would seem that the way to overcome this would be to do away with the high sides and replace them by a system of benches. The latter method is not without its dangers, but that can more easily be lessened by making the benches wide and distributing the men in echelons.

Mention must be made of the recommendations already made regarding the cleaning and scaling of pit and quarry walls. It is essential for the workmen's safety that they be continually cleared of all stones that may have become detached, fissured by frost or by concussion or again thrown upon them by a blast. Some mines have gangs of experienced men who scale the sides thoroughly once or twice a week.

Underground mines are not free from rock falls. The method of getting the ore out by stoping method, generally followed in the Province of Quebec, is not without its dangers. The roof of the rooms may not be solid and it must therefore be watched. The usual plan consists in having gangs specially told off for that work; they must periodically examine the roof and walls carefully and cut down any portion they consider dangerous. That, however, is not sufficient. The mine managers must strongly recommend the drill runners to never begin a cut without making sure that the roof is solid, and frequently remind them of the same.

Cable Derricks:—

As may be seen by Tables V and VI, the method of hoisting ore by means of cable derricks, as followed in asbestos mines, is a very important factor among the causes of accidents. The fact of the derrick box having to run across the whole length of the pit hanging from a cable and also over the men working at the bottom, is a continual menace to their lives. If the cable breaks or the anchors weaken, the whole apparatus drops to the bottom, and a catastrophe happens, for the number of victims is always large in such cases. The method suggested for preventing such accidents consists in thorough and frequent inspections of all parts of the system and especially of the cable. It is preferable that such inspection be made by two machinists alternately and their observations should be noted in the inspection register.

By reading the list of accidents, it will be seen that several workmen have been struck by derrick boxes in motion. These accidents happen most frequently at the moment when the boxes reach the bottom, hanging from a tackle whose pulley blocks are from one to two hundred feet apart. Accidents happen when the box reaches the bottom; the workmen try to stop its swinging and are struck by it. At other times, the engineman does not sufficiently control the descent of the box which comes down too soon upon the gang who are to load it; they have not time to get out of the way and some one is struck. The list shows that several men working at loading the boxes get fingers or a leg crushed. In more than one instance this may be due to the men's carelessness. At Thetford, Black Lake and Danville the rock is rather hard and breaks into large pieces when blasted. The smaller pieces are carried to the box in the arms of the workmen who let them fall heedlessly at the risk of crushing another's fingers; or else the stone falls from their hands, or splits tearing or crushing fingers, falling on a foot, etc.

The practice of chaining the stone blocks is not without danger. It is done for the purpose of causing slides, and the chain is often worked beyond its safety factor; then it breaks and the links become projectiles.

Neither is the unloading of the box effected at the surface without a workman being occasionally injured. The system of automatic unloading, as followed at the King mine is a great step towards preventing accidents.

The danger of overhead conveyance of ore has led several companies to improve hoisting methods. Thus, in 1915, the King mine, by building boxes of greater capacity, reduced the number of cable derricks from thirteen to four. For several years, the Bell mine has had its mine cars run down an inclined plane to the bottom of the open working where they are loaded by a travelling derrick. At the Jeffrey mine, they go still further: the loading of the boxes by workmen and over-head conveyance are replaced by a system of railways on the benches of the pit on which the large mine cars are hauled by locomotives. The loading of the cars is done at the face of the workings by means of powerful mechanical shovels. This method has the twofold advantage of eliminating accidents due to slides and cable derricks. At the Jacobs mine, the walls are vertical owing to the narrowness and depth of the quarry, and as the surface is, moreover, covered with a thick layer of earth reaching to the edge of the pit, being a constant source of danger to the men working at the bottom, the management has decided to give up working in an open cutting and replace it by an underground system. It is intended to do this by the crushing method called "Glory Hole." Quite near the ore bins, it is proposed to sink a shaft four hundred feet deep; from the bottom of it a main-drift through which mine cars will run will be bored throughout the whole length of the property with cross-cuts at intervals; lastly, along the latter will be chimneys ending at the bottom of the pit. When all the preliminary work is finished nothing will be seen at the bottom of the pit but the drill runners who will drill holes around the chimney openings, that is to say, that will widen them in the shape of an inverted cone. When the cutting is ended, the ore will be drawn out at the foot of the chimneys and conveyed to the hoisting shaft.

Explosives:

It will be observed with satisfaction that only a small number of accidents have been caused by the use of explosives in the mines and quarries of the Province of Quebec. Not a single fatal accident has occurred in connection with them during the year. As to non-fatal accidents they consist of 2% of those in mines and 14.3% of those in quarries. This is an improvement over the previous year, when the numbers were 2.4% and 21.4% respectively.

Miscellaneous:

By reading the list of accidents during the year, covered by this report, it will be noted that several accidents were caused by shafting, most of the victims being oilers. In the description of fatal accidents it will be seen that a workman who left fibres of cotton waste hanging out of his coat pocket, was carried around a shaft and killed. Two others had a limb broken while doing the same work. Owing to the rapidity with which shafts revolved the lubricators require to be frequently refilled and the men doing the work are obliged to get close to the bearings when the machinery is in motion. Very few lubricators are to be found in most of the mills. Although self-acting lubricators have repeatedly been tried, none have been found satisfactory. The fine asbestos dust continually floating in the atmosphere mixes with the oil and thickens it so much that it cannot flow in the thin pipes carrying it to the friction point.

It is regrettable to find, on the lists, accidents that should not have happened. Thus, there are three cases of injuries caused by the falling of derrick masts or of tripod beams. A careful examination of the guy-ropes and anchors would prevent the repetition of such unfortunate occurrences.

When a workman has to carry gasoline from one place to another he should do so in a closed vessel. This is an elementary precaution to be taken to prevent sparks, hot cinders and match ends and cigarette stumps from falling in.

In winter, the stairs and inclined ways leading to the bottom of the quarries should be looked after, otherwise ice will form on them and they will become rounded and slippery, thereby occasioning falls.

It is desirable that all openings in floors, as for hoppers, be surrounded by guards to prevent falls through a false step. This is neglected in more than one place. The same applied to pieces of rapidly moving machinery. They should all be surrounded by guards. Fortunately several mills are provided with such protective appliances consisting usually of railing, sheet iron protectors, lattice work, cages, nets, covers or screens, which prevent even the most careless workman from coming in contact with pulleys, belting and other apparatus in motion. All the mills are not model ones in this respect, and it is to be hoped that economy of the prevention of accidents in labour will be understood by a larger number of mine managers; also that, before long, shops and buildings where motive power is used will be provided with such indispensable apparatus. But still more is needed to avoid accidents; such apparatus must be kept in good order and in proper position- and the workmen must be reminded that they owe it to themt selves, to the public and to their comrades to acquire prudens habits and to always act in such a manner as to eliminate all cause, of danger. The management should never cease reminding them of this.

RESPONSIBILITY FOR ACCIDENTS.[1]

"Responsibility for accidents falls both on operators and employees. The management is responsible for the safe condition of the quarry and the equipment; whereas on the workman falls

[1]Technical paper on Safety in Stone Quarrying.—U. S. Bureau of Mines.

the responsibility of exercising proper care and judgment in handling rock, tools, or explosives, and in avoiding dangerous situations.

As regards responsibility, all accidents may be grouped into four classes.

One group comprises those which may be classed as unforeseen, or purely accidental, the results of dangers inherent in the occupation, and unavoidable by any reasonable means. Fortunately, many accidents which were once termed unavoidable are now preventable. Through the invention of new safety devices and the inauguration of safer methods, accidents of this class are steadily decreasing in number, and efforts are constantly directed toward a further decrease.

A second group comprises those accidents for which the responsibility rests on quarry operators. Workmen are obliged to labor under derricks, guys, overhanging rock masses, or otherwise subject themselves to unseen dangers, trusting to the security of the equipment and the judgment of their employers.

Responsibility for a third group falls both on operators and employees. It includes easily recognizable dangers, such as loose scale on quarry roof or wall, boards with projecting nails, icy steps, and weak ladders. Operators should seek to remove such dangers, and employees should report them to their foremen, and use care to avoid them until they are corrected.

For accidents of the fourth group responsibility falls mainly on the workmen. Accidents of this class are to be attributed to carelessness or lack of judgment. They are the result of obvious and ever-present dangers due to careless handling of rock, tools or explosives, and the unnecessary taking of risks in connection with hoisting, quarry cars, etc. Operators can assist in the preservation of lives and limbs by placing danger notices in conspicuous places, by covering gears, belts, and wires, and by making safety rules and insisting upon their observance; but neither equipment nor rules can take the place of watchfulness and judgment on the part of employees. Men are prone to take chances, and having done so many times and escaped injury, the sense of danger is dulled, and greater risks are taken. Sooner or later an accident results, and a lost life or limb is the penalty."

MINES, QUARRIES AND MILLS—PROVINCE OF QUEBEC

FATAL ACCIDENTS DURING THE YEAR 1916

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Accident
1	Jan. 18	Maisonneuve Quarry	Maisonneuve Quarry....	Gaudias Chabot....	18	Apprentice-Machineman......	Unknown.............	Probably suffocated under pile of crushed stone.
2	Mar. 16	British-Canadian...	Asbestos Corporation of Canada.	Edmond Henri.....	24	Driller..........	Crushed to death.......	While placing dynamite under a rock, it rolled down.
3	Mar. 25	King's Mine.......	Asbestos Corporation of Canada.	Joseph Blanchette..	33	Foreman........	Fracture of the skull....	Struck by rock falling from top of side of pit.
4	May 18	Johnson's..........	Johnson's Co..........	Joseph Bernard....	..	Labourer........	Fracture of the skull and limbs.	Crushed under a slide of rock.
	May 18	Johnson's..........	Johnson's Co..........	Eugene Morisette ..	..	Labourer........	Fracture of the skull and and limbs.	Crushed under a slide of rock.
	May 18	Johnson's..........	Johnson's Co..........	Thomas Turcotte...	50	Foreman........	Bruises in head, legs, arms, back hurt.	Crushed under a slide of rock.
5	May 31	Beaver Mine.......	Asbestos Corporation of Canada.	Ovide Giguere.....	24	Oiler............	Instantly killed.........	Cotton waste hanging from pocket caught by shaft.
6	June 4	King's Mine.......	Asbestos Corporation of	Georges Scintulan..	33	Labourer........	Arm torn off, other fractures.	As the derrick box was being hoisted the main cable broke, one end of which struck the victim.
7	Aug. 24	King's Mine.......	Asbestos Corporation of Canada.	Edmond Paquin...	38	Labourer........	Fracture of the skull....	Struck on the head by a rock rolling from side of pit.
8	Sept. 22	Chateau Richer Quarry	Chateau Richer Quarry Company.	Elz. Larouche......	37	Labourer........	....	Covered under a rock slide which occurred a short time after a blast.

FATAL ACCIDENTS DURING THE YEAR 1916—Continued

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Accident
9	Oct. 4	Beaver Mine.......	Asbestos Corporation of Canada.	Jean Beland.......	53	Labourer........	Broken rib in region of the heart.	While taking down some loose rock, some earth and rock slid down on him.
10	Oct. 6	Ruisseau Rouge Quarry	The Ha Ha Bay Sulphite Co. Limited.	Stanislas Poitras....	20	Labourer........	Instantly killed........	Guy stub of derrick pulled out allowing derrick to fall.
11	Nov. 5	Eustis Mine.......	Eustis Mining Co.......	G. Nunzio.........	35	Miner...........	....	Inhalation of poisonous gases.
12	Nov. 9	Jeffrey Mine.......	Manville Asbestos Co., Limited.	Leonidas Hamel....	24	Labourer........	Instantly killed........	As the derrick-box was being hoisted one of the three chains supporting it broke causing the rock in the box to fall on the man.
	Nov. 9	Jeffrey Mine.......	Manville Asbestos Co., Limited.	Napoleon Cormier..	26	Labourer........	Instantly killed.........	As the derrick-box was being hoisted one of the three chains supporting it broke, causing the rock in the box to fall on the man.
13	Nov. 13	Chateau Richer Quarry.	Chateau Richer Quarry Company.	J. E. Baker........	..	Superintendent...	Fracture of the skull....	Struck by a leg of tripod derrick while attempting to remove it.
14	Nov. 24	Delorimier Quarry..	Delorimier Quarry Co...	Horace Dugas......	50	Labourer........	Fracture of the skull....	Fall of a rock at the working face of quarry.
15	Nov. 30	King's Mine.......	Asbestos Corporation of Canada	Laurent Noel......	21	Loader..........	Both legs fractured......	Legs struck by a rock rolling down from a jam.

18th January, 1916—Gaudias Chabot, 18 years old, did not come home at the end of the day and his family searched for him. On the following day, the foreman of the Rosemount quarry, being notified of his workman's disappearance, ascertained that the young man's coat was hanging on its hook, that his overalls were missing and that he had been seen for the last time about four o'clock on the previous afternoon. Remembering that between 11 a.m. and 1 p.m. young Chabot had been working in one of the stone bins, he had the latter emptied. Under a two feet layer of broken stone one inch in diameter, the unfortunate young man was found in a vertical position with no outward marks to denote the cause of his death. A few scratches on his face were to be seen. The face retained its natural expression and usual colour, which dispelled the supposition of his having sunk down in the small stones, of being suffocated under a falling mass of it. The body was found about the middle of the bin which was 15 feet by 30 and 20 feet high. As a shovel was found in the compartment it is supposed that, at the end of the afternoon, Chabot went to get the shovel he had forgotten some hours before. Did he fall? Did he die suddenly? It is impossible to ascertain the exact cause of the accident as there was nobody with him and no *post mortem* examination was made of the body.

VERDICT—Accidental death.

16th March.—At the Standard Pit of the Asbestos Corporation of Canada, Black Lake, Edmond Henri, 24 years old, drill-runner, was rolling blocks of stone down with a companion. After trying in vain to move a large piece of stone weighing several tons, and which lay 10 or 12 feet from the bottom of the pit, he decided to blast it with dynamite. As he was about to put some cartridges behind it, a lot of stones fell, and Henri, not having time to get away, was struck by one. When he was picked up, the doctor, who was hastily summoned, found the skull fractured, as well as three ribs, the right leg, and right arm.

VERDICT.—Accidental death.

25th March—Joseph Blanchette, gang foreman at the King mine, Asbestos Corporation of Canada, Thetford, was superintending the loading of derrick boxes, when a stone fell from a side of the pit and struck him on the back of the skull.

The temperature, which had been cold until the previous day, changed suddenly during the night and in the morning there was a heavy thaw. As a precaution, a man was told off for each gang to watch the side of the pit near which the gang was working, with orders to warn his comrades when ever a stone detached itself from the side of the pit.

About half-past two in the afternoon the watchman of the gang under Blanchette's charge saw a piece of rock start from a point about 200 feet from the bottom of the pit. He gave the danger signal; four men moved away and two remained near the box, because the stone's trajectory was not in their direction. Unfortunately, the stone changed direction and fell on the pile at the foot of which the gang was working. The two men ran away, but a stone struck Blanchette a little below the nape, fracturing the skull. He died at 8.30 the same evening.

VERDICT—Accidental death, with a recommendation to remove the earth on the edge of the pit.

18th May.—At the Johnson mine, Thetford, about two o'clock in the afternoon, a gang of six men were rolling down stone, when a slide occurred carrying away Eugene Morisette, Jos. Bernard and Napoleon Turcotte. Two were instantly killed and the third died a few days later.

A man at the top of the part that slid down, was holding two men by two ropes, when the rock began to slide; he let go everything. One of the men was able to jump on the solid rock, while his companion and two other men, one being the foreman, were covered by the fallen rock. The slide was caused by the dropping of a mass of broken stone 50 feet long, 30 feet wide and 15 feet deep.

The mass of stone on which the gang was working was the result of two blasts, fired some time before.

The facts stated at the inquest seem to indicate that the method followed at that mine for rolling the stones down was inadequate; that every man should be given an assistant while doing such work, and that the ropes should be made fast to posts to ensure proper support.

31st May—Ovide Giguère, oiler, employed by the Asbestos Company of Canada at the Beaver mine, was found dead on the floor under a horizontal shaft around which his clothing was rolled.

As there was no witness of the accident, it seems probable that the victim was oiling the bearings of the shaft which connects cyclone No. 5 directly with the 75 H.P. electric motor. The shaft is seven feet above the floor, is three inches in diameter, and makes 900 revolutions a minute. To oil it, the workman has to go up a solid step-ladder with five steps. In removing the clothing from the shaft under the former and around the latter were found fibres of cotton-waste used for wiping machinery. The inference is that the unfortunate man went too close to the shaft; that the fibres of cotton-waste sticking out of his pocket were sucked in by the draught and rolled around the shaft carrying the victim's clothing with them, and that he, after three-fourths of a turn was hurled on the floor. The doctor who examined the body found a bleeding wound on the head with no fracture, and an indented fracture of the spine in the dorsal region.

The coat was found rolled around the shaft at a place where there was absolutely nothing which could catch the clothing.

5th July, 1916—Fatal accident at the King mine of the Asbestos Corporation of Canada, Thetford Mines. Inquest on the death of George Scintula, 33 years of age, held in the Town Hall, of Thetford Mines, on the 9th July—At the King mine of The Asbestos Corporation of Canada, Thetford Mines, George Scintula, 33 years of age, an Austrian, was one of a party of 45 interned enemy subjects who were working under guard. He was at the bottom of the quarry with some other workmen. A derrick box had just been loaded and the signal to hoist had been given. The box had been lifted two or three feet from the ground when the main cable broke at a point 60 feet from the top and fell to the bottom of the quarry from a height of about 300 feet, killing the victim and injuring four others. The accident occurred at 8.15 p.m. The victim died an hour afterward without recovering consciousness. His skull was fractured in the right temporal region, while the right arm was partly torn off and the right leg fractured.

The engineer in charge of the hoist had noticed nothing wrong, either with his machine nor with the cable. The box contained the usual load. The cable had been inspected on the 1st July. The cable inspector had been engaged in that work for twelve years. The inspection is made every fortnight and the inspector does it by going from one end of the cable to the other, attached to the carrier which rolls on the cable, and taking note of any broken wires.

The cable is $2\frac{1}{2}$ inches in diameter, made of 6 strands of 19 wires each, making 114 wires. Twelve broken wires at the place where the cable parted, had been noted at the last inspection. The corporation's engineer testified that the cable had been made to hoist a weight of 10 tons with a coefficient of safety of 10 or 12; the total weight being hoisted when the accident happened was about $7\frac{1}{2}$ tons. The breaking load of the cable is about 254 tons. A cable of that kind should last several years, and that one had been put on in December, 1915. He could in nowise explain the cause of the cable breaking. An examination of the broken end of the cable showed that some of the wires had stretched as if under a breaking load; a great many showed a jagged surface without any decrease of diameter. There was no sign of any criminal attempt to weaken the cable. The break was jagged and extended over a length of about 30 inches of the cable.

VERDICT—Accidental death due to the fall of a steel cable.

24th August—During the afternoon, Edmond Paquin, 38 years of age, a labourer in the employ of the King Mine of the Asbestos Corporation of Canada, was loading derrick boxes when a small stone, the size of an egg, fell from a height of about 100 feet and struck him on the fore part of the skull. He died 24 hours afterward. Outward examination by a physician revealed a cut in the scalp with bleeding. The skull was intact. The cause of death was attributed to cerebral hemorrhage after an accident during work.

22nd September—At the quarry of the Chateau Richer Quarry Company, Chateau Richer, Elzear Larouche, 37 years of age, was killed about 7.30 a.m. by a stone falling from a pile formed by a blast an hour before. From the beginning of his day's work, Larouche had been trying to pull a big stone out from the foot of the mass, when a stone, displaced by his efforts, caused another lying partly on it to fall on him.

As the district coroner failed to notify the Mines Branch, its engineers were unable to attend at the inquest and to obtain more ample information.

4th October—At the Beaver mine of the Asbestos Corporation of Canada, Thetford, Jean Beland, 54 years of age, a labourer, was working with three others at clearing away the surface earth on the edge of the pit. Having gone too far under without cutting down the upper portion of the face, a lump of earth, estimated to weigh over 100 pounds, detached itself and struck the victim on the chest, breaking a rib. When picked up he was kneeling, and his legs and the upper part of his body were covered by the fallen earth.

He was carried to the hospital, but, owing to his age and bad health, pneumonia set in, and he grew worse until he died on the 9th, at 1 a.m. The physician found that his injury consisted of a rather deep cut in the upper lip, and fracture of a rib on the right side, in the region of the heart.

VERDICT—Accidental death.

6th October—At the Ruisseau Rouge Quarry, belonging to the Ha! Ha! Bay Sulphite Co., Limited, Stanislas Poitras, 17 years of age, a labourer employed by Messrs. Ouellet and Morin, contractors, was killed by a falling derrick.

The apparatus consisted of a mast held in position by long cables anchored at a distance. According to the evidence given by the witnesses, one of the pickets was pulled out under the strain of the cable which it served as an anchor. The mast fell, and Poitras was struck on the head. His instantaneous death was attributed to deep fracture of the skull.

VERDICT—Accidental death, caused by the fall of a derrick.

5th November—At 8.30 a.m. at the Eustis Mine, G. Nunzio, 35 years of age, a labourer in the employ of the company for six months, was working with four or five others at shovelling the rock broken by a recent blast at the bottom of the hoisting shaft. The heavy gases from the explosion of the dynamite hung about the lower part of the shaft, and the swinging of the water bucket stirred up the gases which suffocated the workmen.

When the physician arrived, the heart beats of the victim, G. Nunzio, were very weak and rapidly grew weaker. He died an hour and a half afterward. His nose was broken and there were scratches on his face, due probably to his falling down when asphyxiated.

The foreman in charge of the gang asserted that he had examined the spot an hour before the accident and did not detect the presence of any gas.

The last blast had been fired the previous evening, at the top of a raise starting from level 3,300.

It is only when the foreman detects the presence of gas in a working that the air-pipe is turned in that direction.

The explosives used were fulminate caps and 40% Forcite dynamite.

VERDICT—Accidental death, with a recommendation to always ventilate the workings after blasts are fired.

13th November—At the quarry of the Chateau Richer Quarry Company, while J. E. Baker, the superintendent, was overseeing the tamping of some blast-holes, through some unaccountable cause, a tripod derrick fell and struck him on the head, killing him almost instantly.

24th November—Horace Dugas, 50 years of age, a quarryman in the employ of the Delorimier Quarry Company, Montreal, was killed by a piece of rock falling from a height of nearly 40 feet.

The accident occurred about 9 a.m. at the northern end of the quarry, while the victim was making a hole at the foot of a fallen mass with an iron bar.

During the year, stone had been blasted with explosives only twice. At the place where the accident happened the rock had been mined in the spring. The mining is usually done by making holes 40 feet deep. The rock is limestone, in horizontal strata. After the blasts are fired, the rock has many wide vertical fissures. Through some unknown cause—perhaps the vibration occasioned by the blows of the bar—a large block fell and struck the victim.

VERDICT—Death caused by the skull being crushed through an accident.

31st November—At the King mine, about 8.25 p.m., Laurent Noel was struck on the legs by a piece of rock falling from a side of a pit. He died on the 4th December at the St. Joseph's Hospital, Thetford, from cerebral complication due to fracture of the legs. According to the evidence at the inquest, a piece of rock weighing about 300 pounds started from the top of a fallen mass and rolled in the direction of a gang of four men who were loading a derrick box at the southern end of the pit. The top of that mass was about one hundred feet above the bottom of the pit. The slope was about 45 degrees. When the foreman in charge of the work at the bottom of the pit called to the men to get out of the way, they looked up, hesitated for a moment, and ran away. The two men working at the ends of the box had room to get clear. The two others had to go parallelly to the base of the slope, as far as the end of the box or jump into the latter, whose sides were 27 inches high and 9 feet long. The first and most natural alternative was instinctively adopted. As Laurent Noel was about to go around the box, the rock struck his legs, fracturing the right one in the lower part and the left one in the middle, causing also a wide wound below the left knee. Cerebral complications occasioned by those injuries were the immediate cause of his death.

The pit of the King mine is sufficiently lighted at night by means of eight lamps of 1000 watts power.

VERDICT—Accidental death.

MINES, QUARRIES AND MILLS—PROVINCE OF QUEBEC

NON-FATAL ACCIDENTS DURING THE YEAR 1916*

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Accident
1	Jan. 5	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Joseph Cloutier	29	Labourer	Contused wound left foot	While assisting to unload a car of rails one of the rails fell on injured's left foot.
2	Jan. 11	Jacob's Mine	Jacobs Asbestos Mining Co.	John Simonuk	24	Pit Labourer	Left foot bruised	A stone fell on his foot.
3	Jan. 15	Jacobs Mine	Jacobs Asbestos Mining Co.	Jos. Provost	26	Mill Labourer	Little finger of right hand split.	A piece of iron fell on his finger.
4	Jan. 15	British Canadian	Asbestos Corporation of Canada	Alcide Turcotte	27	Labourer	Toes of left foot amputated.	A piece of rock rolled down from a pile and crushed the toes of his left foot.
5	Jan. 15	Jeffrey Mine	The Asbestos & Asbestic Co. Limited.	Edward Murphy	68	Labourer	Contusion and sprain of right side.	Injured slipped on the ice and fell.
6	Jan. 17	Jeffrey Mine	The Asbestos & Asbestic Co. Limited.	Elia Nehrucak	35	Labourer	Contusion of right hand.	Empty box swinging caught injured's hand between it and a large piece of rock.
7	Jan. 19	King's Mine	Asbestos Corporation of Canada	Philippe Roy	53	Labourer	Left eye injured	While cleaning an air-drill a little piece of rock struck his left eye.
8	Jan. 26	British Canadian	Asbestos Corporation of Canada	Edmond Marceau	47	Labourer	Right leg fracture, above ankle.	A piece of rock from rolling down from a jam, caught him and broke his leg.
9	Jan. 29	Jacobs Mine	Jacobs Asbestos Mining Co.	A. Cote	22	Driller	Cut on forehead	A nut from a pit block fell and struck him on the head.
10	Feb. 3	Kings Mine	Asbestos Corporation of Canada.	Leontig Jawdosyko	43	Labourer	Serious contusion and wound to the big toe of left foot.	While loading ore-box a stone fell on his foot.
11	Feb. 7	Jeffrey Mine	The Asbestos & Asbestic Co. Limited.	Antonio Paradis	26	Brakeman	Contusion of right hand	Fell from dumping car.
12	Feb. 8	Granite Quarry	The Laurentian Granite Quarry Co.	Alphonse Leroux	38	Quarryman	Fractured bone in leg	While handling stone to the crusher, one stone rolled from pile striking him on leg.

* Incapacitating the victim for ten days or more.

13	Feb. 10	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Alfred Fenn.......	21	Labourer........	Fracture of tibia & fibula	Piece of rock fell from side of pit on injured's left side.
14	Feb. 11	Jacobs Mine.......	Jacobs Asbestos Mining Co.	O. Gingras........	19	Pit Labourer.....	Big toe on left foot cut..	A stone fell on his foot.
15	Feb. 12	British Canadian...	Asbestos Corporation of Canada.	Alfred Thibodeau..	30	Labourer........	Left knee & leg bruised..	While taking down some "loose" a piece of rock rolled down striking his left leg.
16	Feb. 12	Beaver Mine.......	Asbestos Corporation of Canada.	Honore Paquette...	24	Labourer........	Thumb, index and little finger of right hand bruised.	Paquette was loading rock in a derrick-box when one of his companions accidently threw a piece of rock on his hand.
17	Feb. 14	Beaver Mine.......	Asbestos Corporation of Canada.	Zenon Roy........	40	Labourer........	Part of third finger severed.	Roy was placing a large stone into the hoist-box when his finger was caught between the stone and the box.
18	Feb. 15	Weedon Mine......	Weedon Mining Company.	Joseph Bariault....	19	Mucker.........	Tip of third finger of right hand badly crushed.	The injured man was working on a plot when a big rock fell and crushed finger.
19	Feb. 15	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	Thomas Gifford....	57	Labourer........	Contusion of right fore-arm.	Piece of rock rolled down on injured's arm.
20	Feb. 15	Jeffrey Mine.......	The Asbestos & Asbestic Co.	Frank Perkins.....	27	Engine driver....	Lacerated wound middle finger left hand.	Caught his fingers between cross head and cylinder of locomotive.
21	Feb. 16	British Canadian...	Asbestos Corporation of Canada.	Arthur Carrier.....	18	Labourer........	Cut across corner of left eye.	While a fellow workman was sledging rock a piece of it struck injured in left eye
22	Feb. 17	Beaver Mine.......	Asbestos Corporation of Canada.	Nap. Trepanier....	51	Labourer........	Big toe of left foot bruised.	A large stone slipped from his hand falling on his foot.
23	Feb. 17	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	Thomas Brochu ...	23	Labourer........	Fracture of tibia & fibula contused wound lower jaw.	Three pieces of rock fell on injured's leg.
24	Feb. 17	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Thomas Jarosek....	28	Labourer........	Contusion first finger right hand.	Stone rolled down on injured's finger.
25	Feb. 18	Jacobs Mine.......	Jacobs Asbestos Mining Co.	N. Hutzkan........	26	Pit Labourer.....	Right leg broken above ankle.	A stone rolled from top of jam, striking him on leg.
26	Feb. 22	Jacobs Mine.......	Jacobs Asbestos Mining Co.	M. Duhanuk......	31	Pit Labourer.....	Right foot bruised......	A pit box struck him on foot.
27	Feb. 24	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Benj. Lawrence....	35	Labourer........	Contusion of right side..	Injured slipped and fell in bottom of pit.
28	Feb. 25	King's Mine.......	Asbestos Corporation of Canada.	Alphonse Hebert...	27	Labourer........	Suffering from a wound the corner of right eye.	While breaking stone a little piece of stone struck his right eye.
29	Feb. 25	Kings Mine........	Asbestos Corporation of Canada.	Donat Breton......	21	Labourer........	Contusion to inferior part of right leg.	A stone which rolled from a jam struck his leg.
30	Feb. 28	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Alfred Paradis.....	22	Brakeman.......	Contusion middle right finger.	Finger crushed between side of car and a piece of rock.

NON-FATAL ACCIDENTS DURING THE YEAR 1916—Continued

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Accident
31	Feb. 28	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Henri Dupuis......	30	Labourer........	Contusion of left thigh..	Injured was jammed between hoisting box and a piece of rock.
32	Mar. 1	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Hormidas Lemay...	16	Signaller........	2nd and 3rd fingers right hand crushed.	Large piece of rock rolled over on injured's hand.
33	Mar. 3	Kings' Mine.......	Asbestos Corporation of Canada.	Narcisse Bedard....	58	Labourer........	Left eye injured........	In the act of breaking a rock a small piece flew and struck him in the eye.
34	Mar. 4	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Oliva Michaud.....	22	Driller..........	Sprain of right ankle....	Fell from the rock he was drilling.
35	Mar. 4	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Sidney Bristow.....	31	Labourer........	Contused wounds 2nd & 3rd fingers right hand.	Piece of rock slipped from injured's fingers and caught same between the rock and side of box.
36	Mar. 8	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Amede Boutin.....	29	Driller..........	Infection of right thumb.	Small piece of cable went into injured's thumb.
37	Mar. 11	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Joseph Belisle......	26	Labourer........	Contusion of left foot...	Piece of rock fell on injured's foot.
38	Mar. 11	Scottish Canadian..	Scottish Canadian Magnesite Co.	Mike Petrozance...	21	Labourer........	Fracture of thigh.......	The key of foot plate of stiff leg of derrick broke causing derrick to fall.
39	Mar. 11	Scottish Canadian..	Scottish Canadian Magnesite Co.	Bill Drapate.......	20	Labourer........	Slight fracture of skull..	The key of foot plate of stiff leg of derrick broke causing derrick to fall.
40	Mar. 13	Beaver Mine.......	Asbestos Corporation of Canada.	Geo. Pinette.......	18	Labourer........	Left knee bruised.......	A rock rolled from side of pit striking his knee.
41	Mar. 17	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Francois Mercier...	23	Labourer........	Contused wounds little finger, right hand.	Rock fell and crushed injured's finger.
42	Mar. 17	Jeffrey Mine.......	The Asbestos & Asbestic Co. Limited.	Adelard Gauthier...	26	Labourer........	Contused wound right foot.	Piece of rock rolled down on injured's foot.
43	Mar. 18	Kings Mine........	Asbestos Corporation of Canada.	Petro Kuczerka....	32	Labourer........	Contusions of both knees	While loosening a jam a rock rolled down striking victim on knees.
44	Mar. 20	Bell's Mine........	Bell Asbestos Mines....	F. Lapierre........	44	Foreman........	Right ankle sprained....	Big stone rolled on his right foot.
45	Mar. 20	Bell's Mine........	Bell Asbestos Mines....	E. Rousseau.......	38	Labourer........	Right side of head cut 2½ inches long, also contusion on shoulder.	Stone rolling down struck his head and shoulder.

46	Mar. 21	St. Marc Quarry....	La Cie. des Carrieres de St. Marc.	Azarias Turcotte...	..	Labourer........	Foot crushed...........	A piece of timber fell on his right foot.
47	Mar. 22	Kings Mine........	Asbestos Corporation of Canada.	Oleksa Fedorink....	28	Labourer........	Serious contusion of the thigh and an open fracture of both bones of the third inferior part of right leg.	While loosening a jam a rock rolled down and struck his leg.
48	Mar. 23	Kings Mine........	Asbestos Corporation of Canada.	Alfred Tardif......	23	Labourer........	Contusion of right knee.	Was struck by a rock which rolled from a jam.
49	Mar. 27	Johnson's..........	Johnson's Co..........	Magloire Routhier..	55	Labourer........	Infection of an eye.....	By a small piece of rock.
50	Mar. 28	British Canadian...	Asbestos Corporation of Canada.	Albert Cantin......	18	Labourer........	Right index finger bruised.	While drilling his finger was caught between bushing and drill steel.
51	Mar. 31	Weedon Mine......	Weedon Mining Co., Limited.	J. Martinson.......	23	Mucker..........	Big toe of right foot crushed.	By a stone rolling down a stope.
52	Mar. 31	Weedon Mine......	Weedon Mining Co., Limited.	Alphonse Gauthier.	39	Stoperman.......	Left hand badly bruised.	Injured hand caught between plat and mine car.
53	Apr. 2	Weedon Mine......	Weedon Mining Co., Limited.............	C. Ostroki.........	33	Stoper.........	Left knee sprained......	In starting to drill a large piece of rock fell on his knee
54	April 4	King's Mine.......	Asbestos Corporation of Canada.	Alfred Halley......	20	Labourer........	Right wrist sprained....	He caught his wrist between two dump cars in motion.
55	April 5	Weedon Mine......	Weedon Mining Co., Limited.	Homer Fontaine...	21	Mucker..........	Right leg badly bruised..	Rock fell on injured man's leg.
56	April 6	Jacobs Mine.......	Jacobs Asbestos Mining Co.	Joseph Marchand...	30	Pit Labourer.....	Cut on head...........	A stone fell from the edge of the pit and struck him on head.
57	April 7	Kings Mine........	Asbestos Corporation of Canada.	F. Petelka.........	50	Labourer........	Left foot bruised.......	A piece of rock which rolled from a jam struck his foot.
58	April 8	Jacobs Mine.......	Jacobs Asbestos Mining Co.	N. Smith..........	23	Pit Labourer.....	Third finger of right hand bruised and nail off.	Caught finger between stones while loading a box.
59	April 10	Jacobs Mine.......	Jacobs Asbestos Mining Co.	T. Vaillancourt.....	28	Mill Boss.......	Index finger of left hand badly broken and amputated.	Caught his finger in an elevator while repairing same.
60	April 10	Kings Mine........	Asbestos Corporation of Canada.	Joseph Trehan.....	37	Labourer........	A cut on the head......	A small piece of rock rolled from a jam and struck him on the head.
61	April 11	Kings Mine........	Asbestos Corporation of Canada.	Pierre Aubut.......	55	Labourer........	A cut on the head......	A piece of asbestos fell from the side of the pit striking him on the head.
62	April 11	Johnson's..........	Johnson's Co..........	Ernest Paquet.....	25	Labourer........	Scalp wound...........	A stone from side of the pit struck him on the head.
63	April 14	Jacobs Mine.......	Jacobs Asbestos Mining Co.	Thomas Bisson.....	..	Labourer........	Right knee bruised.....	A rock struck him on the knee.
64	April 17	Bell Mine..........	Bell Asbestos Mines....	Leonidas Cote.....	29	Yardman........	Big toe of left foot badly bruised.	Injured was loading car, when another man let drop a truck on the injured man's foot.

NON-FATAL ACCIDENTS DURING THE YEAR 1916—Continued

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Accident
65	April 17	Martin-Bennett....	The Martin-Bennett Asbestos Mines Co......	Pierre Gregoire.....	..	Carpenter...	Bone of one finger broken	While cutting off the head of a bolt he struck himself with a hammer.
66	April 22	Jacobs Mine.......	Jacobs Asbestos Mining Co.	Jos. Jolicoeur......	18	Pit Labourer.....	Contusion of chest and stomach.	Fell coming down a dump.
67	April 22	Kings Mine........	Asbestos Corporation of Canada.	Joseph Lavoie......	22	Labourer........	Fracture of the left thumb.	Hit by a heavy hoisting chain in motion.
68	April 26	Kings Mine........	Asbestos Corporation of Canada.	Joseph Argouin....	24	Labourer........	Left hip injured........	While some men were letting down loose rock from the side of pit, one heavy piece broke on its way down and one of the pieces struck this man.
69	April 28	Kings Mine........	Asbestos Corporation of Canada.	Alphonse Jacques...	19	Labourer........	Left hand bruised......	A piece of rock fell on his hand bruising it as he was loading a derrick box.
70	April 28	Jacobs Mine.......	Jacobs Asbestos Mining Co.	O. Vachon.........	33	Pit Labourer.....	Right eye bruised......	Struck in the eye by small piece of rock.
71	May 1	Jacobs Mine.......	Jacobs Asbestos Mining Co.	A. Marchand.....	25	Pit Labourer.....	Contusion of the head and right shoulder.	Struck on head and shoulder by pit box.
72	May 5	Martin-Bennett....	The Martin-Bennett Asbestos Mines.	Wilfrid Gregoire...	22	Pit Labourer.....	Compound fracture of thumb.	While dumping a car of rock got his thumb caught between rocks, the box and a rock causing a flesh wound on right leg.
73	May 5	Kings Mine........	Asbestos Corporation of Canada.	Louis Binette......	55	Pit Laborer......	Right foot bruised......	While he was loading rock in a box a piece of rock fell on his foot.
74	May 9	British Canadian...	Asbestos Corporation of Canada.	Nytro Choma......	44	Pit Labourer.....	Bruise and cut in the middle of the right leg about five inches long.	He was steadying the pit-box before it started up and he got his leg caught between the box and a rock causing a flesh wound on right leg.
75	May 10	Beaver Mine.......	Asbestos Corporation of Canada.	William Lainé......	50	Pit Labourer.....	A small piece of rock in right eye...........	While breaking rock with sledge hammer a small piece struck him in the eye.
76	May 10	Bell Mine.........	Bell Asbestos Mines....	Ovide Fugère.....	51	Hoistman.......	Three ribs pressed in his lungs..............	Injured caught between platform and a car.

77	May	11	Johnson's........	Johnson's Co........	Onesime Vaillancourt	55	Joiner..........	Amputation of tips of middle fingers of left hand..............	While starting to plane a piece of board in planer, the board jumped and hand slipped.
78	May	15	Kings Mine........	Asbestos Corporation of Canada.	Adelard McGee....	18	Labourer.......	Left side injured.......	This man was pulling a hoisting rope when he slipped and fell on a piece of rock
79	May	19	Lime Quarry.......	The Dominion Lime Co.	Thomas Brosseau...	61	Foreman........	Fracture of several ribs on right side with laceration of lung, fracture of both forearms.	Was oiling bearings of pulley that runs stone pulverizer.
80	May	19	Bell Mine.........	Bell Asbestos Mines....	Arthur Després.....	20	Pit Labourer....	Inside part of left thigh contused...........	A stone rolled down from a pile and jammed the victim between it and another rock
81	May	22	Bell Mine.........	Bell Asbestos Mines....	Jos. Matte.........	59	Pit Labourer....	Left leg injured right below knee cap.........	When breaking a stone with a sledge hammer a piece of that stone broke off and struck his leg.
82	May	22	Beaver Mine.......	Asbestos Corporation of Canada.	John Henley.......	56	Labourer........	Second finger of right hand bruised.	While placing a stone in the derrick-box it slipped bruising his finger.
83	May	22	Zinc Mine.........	Weedon Mining Co., Limited.	J. W. Fournier.....	..	Labourer........	Left hand badly bruised by gasoline explosion.	Probably a spark from the stack dropped into the vessel in which the victim was carrying gasoline.
84	May	26	British Canadian...	Asbestos Corporation of Canada.	Adonis Breton.....	19	Labourer........	Bruise on right hip.....	Accidently hit by a piece of iron which was being handed over to him.
85	May	30	Weedon Mine......	Weedon Mining Co., Limited.	Louis Biron........	22	Mucker.........	First finger of left hand crushed.	While mucking a rock rolled down the stope and rolled on the injured's hand.
86	May	31	Jeffrey Mine.......	The Asbestos & Asbestic Co.	Theo. Champagne..	25	Labourer........	Contused wound of left great toe.	Caught his foot between car and engine.
87	June	2	Kings Mine........	Asbestos Corporation of Canada.	Ludger Gagné......	21	Labourer......	Left foot bruised.......	Gagné was loading rock into a box when another box in motion struck his foot.
88	June	3	Kings Mine........	Asbestos Corporation of Canada.	Ernest Richard....	30	Bagger..........	Sprained his left wrist...	While bagging fibre he sprained his wrist.
89	June	6	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	Adelard Belisle.....	31	Boxman........	Contused wound of left ankle.	Piece of rock fell on his ankle.
90	June	10	Jacobs Mine.......	Jacobs Asbestos Mining Co.	J. Kesiluk.........	35	Labourer........	Left foot and right leg bruised.	Struck by a pit box.
91	June	13	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	Patrick Keraluk....	48	Boxman.........	Laceration of first finger.................	Piece of rock rolled on injured's hand.
92	June	16	British Canadian...	Asbestos Corporation of Canada.	Ivan Orskuski......	45	Labourer........	Left foot bruised.......	Was loading a derrick box when a rock rolled on his foot.

NON-FATAL ACCIDENTS DURING THE YEAR 1916—Continued.

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Injury
93	June 17	British Canadian...	Asbestos Corporation of Canada.	T. Tousignant.....	53	Labourer........	Sprained hand.........	In moving a rock.
94	June 19	Jacobs Mine.......	Jacobs Asbestos Mining Co.	A. Nadeau........	27	Pit Labourer.....	Left eye bruised........	A flying stone struck him in the eye.
95	June 21	British Canadian...	Asbestos Corporation of Canada.	Nicholas Andronic..	48	Labourer........	Toes of right foot bruised	A piece of rock fell on his foot.
96	June 24	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	W. Lanneville......	36	Chainer.........	Fracture of right fibula..	Rock rolled down on injured's ankle.
97	June 26	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	Ludger Lefebvre...	28	Boxman.........	Contused wound right middle finger.........	Finger infected through having a pimple on it.
98	June 27	Weedon Mine......	Weedon Mining Co., Limited.	Georges Allard.....	29	Timberman......	Internal injuries in left side................	Thrown about ten feet by big sheet of steel while putting plate sheet on bin chutes.
99	June 28	Johnson's Mine....	Johnson's Co..........	Bill Tapiak........	35	Labourer........	Injury to right eye.....	Struck in the eye by a small piece of stone.
100	June 30	British Canadian...	Asbestos Corporation of Canada.	Theodore Henri....	33	Driller..........	Cut on the head........	In taking down loose rock he lost his balance and fell.
101	June 30	American Mine.....	North American Magnesite Co. Limited.	Pizzat Guiseppe....	..	Labourer........	Right forearm fractured.	By flying rock from blast.
102	July 4	Weedon Mine......	Weedon Mining Co., Limited.	Emile Ducharme...	24	Stoper..........	First finger of left hand badly split...........	While pitching a hole he had his finger caught between the wall and the valve of his stoper.
103	July 4	Baker Quarry......	Chateau Richer Quarry Co.	Albert Lambert....	41	Powderman......	Serious injuries.........	Electric caps exploded in right hand, said to have been struck by a small rock falling from face.
104	July 6	Beaver Mine.......	Asbestos Corporation of Canada.	Joseph Grenier.....	54	Labourer........	Left foot bruised.......	While loading a derrick box some rock from a jam rolled down.
105	July 7	Jacobs Mine.......	Jacobs Asbestos Mining Co.	John Edwards......	55	Blacksmith......	Deep cut in right hand..	As helper was hammering a bar of steel, a piece broke off and struck him on the back of his hand making a deep cut and lodging between bones.
106	July 8	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	Joseph Boucher....	38	Boxman.........	Contusion and sprain of right ankle joint......	Injured dropped a piece of rock on his foot.

107	July 10	Eustis Mine	Eustis Mining Co.	Thos. Johnson	36	Labourer	Big toe of right foot crushed	He was standing in a stope when a big rock rolled down
108	July 11	Kings Mine	Asbestos Corporation of Canada.	Pierre Hebert	31	Carpenter	Third finger of left hand bruised	A piece of iron fell on his finger.
109	July 12	Jeffrey Mine	The Asbestos & Asbestic Co. Limited.	Andre Lemenent	46	Mill hand	Wound to the cornea	Piece of stone flew to his eye.
110	July 13	Jacobs Mine	Jacobs Asbestos Mining Co.	A. Blais	23	Labourer	Right thumb bruised and cut	Thumb cut between chain and drill.
111	July 18	Jeffrey Mine	The Asbestos & Asbestic Co. Limited.	Joseph Bourassa	51	Truckman	Compound fracture middle finger right hand	Caught his finger while dumping a box.
112	July 19	British Canadian	Asbestos Corporation of Canada.	Pierre Chretien	54	Labourer	Cut to the middle finger of right hand	The lorry came off a track and a fellow workman in moving a rock happened to strike this man on the finger.
113	July 22	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Onesime Roux	..	Boxman	Acute conjunctivitis	Small piece of stone flew into his eye.
114	July 26	British Canadian	Asbestos Corporation of Canada.	Adolphe Ardoin	69	Labourer	Left leg bruised	In placing a derrick box he was caught between it and a rock.
115	July 27	Quarry No. 1	Bennett & Martin Chrome Mines.	Charles Turgeon	33	Driller	Left leg broken	Fell from side of quarry to bottom, about 15 feet.
116	Aug. 1	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Midace Leblanc	25	Driller	Scalp wound over frontal bone	Stone dropped and struck him on the head.
117	Aug. 1	Martin-Bennett	The Martin-Bennett Asbestos Mines.	Noel Gagnon	52	Labourer	Back of leg hurt	Was caught by derrick box descending into pit.
118	Aug. 2	Jacobs Mine	Jacobs Asbestos Mining Co.	Domino Fitzgerald	35	Carpenter	Cut on right hand	On piece of ragged metal.
119	Aug. 3	Martin-Bennett	The Martin-Bennett Asbestos Mine.	Wm. de Grandmont	27	Labourer	Foot crushed	While getting a box of earth along a rollway his foot was caught under one of the rollers.
120	Aug. 3	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Valere Haince	48	Boxman	Contused wound 2nd and 3rd fingers left hand	Caught his fingers between a piece of rock and box.
121	Aug. 8	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Napoleon Boucher	..	Boxman	Amputation of tip of finger	Caught his hand between two rocks.
122	Aug. 11	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Henri Bazin	..	Track hand	Fracture of seventh right rib.	Struck by car.
123	Aug. 14	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Ernest Ouellette	..	Blaster	Sprain muscles of right lumbar region	Slipped and sprained his back.
124	Aug. 14	British Canadian	Asbestos Corporation of Canada.	Lazare Drouin	25	Driller	Bruises on legs, back and shoulders	In taking down a jam of rock he was carried downwith it
125	Aug. 19	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Edgar Boucher	..	Boxman	Contused wound second finger right hand.	Dropped stone on finger.

NON-FATAL ACCIDENTS DURING THE YEAR 1916—Continued.

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Accident
126	Aug. 22	Weedon Mine	Weedon Mining Co., Limited.	Joseph Tetreault	45	Driller	May lose sight of right eye	While blasting in loose rock a small rock rolled down the stope and struck him in the eye.
127	Aug. 24	Martin-Bennett	The Martin-Bennett Asbestos Mines.	J. B. Picard	42	Labourer	Toe of right foot broken.	While lifting stone to put in derrick box, the rock broke in two, one piece falling on his foot.
128	Aug. 24	British Canadian	Asbestos Corporation of Canada.	Mathias Champagne	26	Labourer	Bruises	In pulling a car he was squeezed between car and waggon.
129	Aug. 24	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	John Arsenault	..	Boxman	Contused wound right arm.	Was struck by a box.
130	Aug. 24	Laprairie Plant	National Brick Co. of Laprairie Limited.	Damien Roy	15	Trucker	Right leg bruised above ankle	Runway had been taken up to allow shunting engine to pass but had not been set back far enough. Bumper of locomotive caught runway causing it to swing around and jamming the victim's leg against the wall.
131	Aug. 26	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Vogtek Vognovick	..	Boxman	Abrasion of skin over frontal bone	Struck by descending derrick box.
132	Aug. 26	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Alfred Nouris	..	Millman	Ulceration of cornea	Piece of asbestos lodged into his eye.
133	Aug. 30	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Joseph Cloutier	..	Millman	Fracture of middle toe	Piece of rock rolled on his toe.
134	Aug. 31	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Archer Roux	..	Chainer	Contusion outside of left leg.	Piece of rock rolled down on his leg.
135	Sept. 1	Federal Mine	Federal Asbestos Co.	Louis Nadeau	18	Labourer	Wound to the right knee	By a stone falling from a car which he was loading.
136	Sept. 4	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Ferdinand Lariviere	..	Boxman	Contusion of foot	Piece of rock rolled down on injured's foot.
137	Sept. 5	Jeffrey Mine	The Asbestos & Asbestic Co., Limited.	Eugene Leblanc	..	Bagger	Contused wound ring finger left hand.	Stuck needle into his hand.

138	Sept. 11	Jacobs Mine.......	Jacobs Asbestos Mining Co.	L. Migneault......	35	Pit labourer.....	Right knee bruised.....	Struck by swinging box and had leg crushed between box and rock.
139	Sept. 11	Villeray Quarry....	Villeray Quarry Company.	Ovila Dagenais.....	44	Quarryman.....	Right arm broken, left leg broken..........	Loose stone dislodged from side of quarry and fell upon injured.
140	Sept. 13	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	John Prince........	..	Labourer.......	Contused wound third finger left hand.......	While putting rock in box injured slipped back and caught finger.
141	Sept. 20	Jeffrey Mine.......	The Asbestos & Asbestic Co., Limited.	Desire Boucher.....	..	Driller.........	Sliver in left hand second finger...............	Struck by sliver of iron from wedge.
142	Sept. 20	Beaver Mine.......	Asbestos Corporation of Canada.	P. Ivanistzki......	31	Pit labourer.....	Small bone in right foot fractured..........	Foot was caught between hoist box and a rock.
143	Sept. 22	Bell Mine..........	Bell Asbestos Mines....	Jean Savoie........	48	Trackman......	Big toe of right foot bruised............	Dropped a piece of rail on his foot.
144	Sept. 23	Bell Mine..........	Bell Asbestos Mines.. .	J. E. Gregoire......	47	Pit labourer......	Left wrist twisted and strained............	Injured was handling and rolling a big stone.
145	Sept. 25	Jacobs Mine.......	Jacobs Asbestos Mining Co.	F. Moroz..........	46	Pit Labourer.....	Left arm broken above wrist, left leg broken and side bruised.	Was struck by cable derrick block.
146	Sept. 25	Laprairie Plant.....	The Laprairie Brick Co. Limited.	Emilien Roy.......	48	Foreman.......	Right leg broken at ankle	Missed footing and fell into shale chute eight feet high.
147	Sept. 26	Jacobs Mine.......	Jacobs Asbestos Mining Co.	Alex. Marcoux.....	17	Pit Labourer....	Right ankle sprained and bruised..............	A stone rolled from a jam onto his foot.
148	Sept. 26	Kings Mine........	Asbestos Corporation of Canada.	Onesime Gagne....	60	Labourer.......	Pain in chest..........	While lifting a piece of rock, he felt a pain in his chest and had to quit work.
148	Sept. 26	Union Mine........	Black Lake Asbestos & Chrome Co.	A. Lagrange.......	30	Labourer.......	Rock fell on toe........	Rock slipped.
150	Sept. 29	Bell Mine..........	Bell Asbestos Mines....	Donat Neault......	22	Electrician.......	Cut of scalp and contusion of left elbow.....	When climbing a post, it fell down and threw the man on the ground.
151	Sept. 30	Federal Mine......	Federal Asbestos Co....	Arthur Metivier....	..	Labourer.......	Cut to the left wrist....	By a rock falling from a pile.
152	Oct. 2	British Canadian...	Asbestos Corporation of Canada.	Marius Lanary.....	23	Labourer.......	Finger bruised.........	Caught between a rock and dumping box.
153	Oct. 5	Federal Mine......	Federal Asbestos Co....	Alfred Lemelin.....	39	Brakeman......	Cut to left wrist........	Struck on the wrist by a stone falling off a car.
154	Oct. 12	Martin-Bennett....	The Martin-Bennett Asbestos Mines.	Damase Gagne.....	32	Labourer.......	Cut to finger and blood poisoning.	Cut himself on a piece of rock.
155	Oct. 18	Jacob Mine........	Jacobs Asbestos Mining Co.	Louis Lessard......	32	Pit Labourer.....	Right foot badly bruised.	A crow bar fell on his foot.
156	Oct. 21	Beaver Mine.......	Asbestos Corporation of Canada.	Alfred Trumelle....	23	Labourer.......	Left side bruised.......	In trying to get out of the way of a rope he bruised his side against wall of the pit.

NON-FATAL ACCIDENTS DURING THE YEAR 1916—Concluded

Nos.	Date	Mine or Quarry	Name of Operator	Name of Injured	Age	Occupation	Nature of Injury	Cause of Accident
157	Oct. 24	Beaver Mine.......	Asbestos Corporation of Canada	Pierre Fradette.....	26	Brakeman.......	Thumb bruised.........	He slipped bruising his thumb against the coupling of the car.
158	Oct. 30	Laprairie Plant.....	National Brick Company of Laprairie, Limited..	Edgar Dumas......	37	Labourer........	Left cheek bruised and eye blackened........	Was sawing old R.R. ties on circular saw. He picked up a short piece to throw to one side when he let it drop on saw, it flew up and struck him on the eye.
159	Nov. 4	Federal Mine......	Federal Asbestos Co....	Theodore St. Hilaire.	48	Fireman.........	Bruised finger..........	While firing his finger was caught between two pieces of wood.
160	Nov. 8	Beaver Mine.......	Asbestos Corporation of Canada.	Jean Nadeau.......	19	Pit Labourer.....	Left knee injured.......	A few bags of fibre rolled down on him hurting his knee.
161	Nov. 11	Bell Mine.........	Bell Asbestos Mines....	Adelard Grondin...	30	Car loader.......	Big toe of right foot bruised.	Small stone jammed his foot against a platform.
162	Nov. 14	Kings' Mine.......	Asbestos Corporation of Canada.	Thomas Lagueux...	23	Labourer........	Right foot bruised......	Was struck by an ore box in motion.
163	Nov. 14	Kings' Mine.......	Asbestos Corporation of Canada.	Alphonse Corriveau.	30	Labourer........	Right hand bruised.....	Due to a rolling stone which fell from side of the pit.
164	Nov. 24	American Mine....	North American Magnesite Co.	M. Landriault.....	..	Labourer........	Lost left eye...........	Premature blast while tamping powder in hole.
165	Nov. 26	Federal Mine.......	Federal Asbestos Co....	Emile St. Hilaire...	17	Oiler............	Broken arm............	Used an empty bag to press a grease cup on an eccentric and the piece of bag stuck to the shaft, catching the arm.
166	Nov. 28	Delson Plant.......	National Brick Co. of Laprairie.	C. Boire...........	19	Off-bearer.......	Cut on forehead........	Was taking down rock holder when it slipped hitting him on forehead.
167	Nov. 28	Beaver Mine.......	Asbestos Corporation of Canada.	C. C. Lessard......	49	Labourer........	Foot bruised...........	Hit by a piece of iron which dropped from his hand.
168	Nov. 30	Kings' Mine.......	Asbestos Corporation of Canada.	Thomas Girard.....	32	Labourer........	Back slightly bruised ...	Hit by some falling stones.
169	Dec. 1	Kings' Mine.......	Asbestos Corporation of Canada.	Wilfrid Turcotte...	26	Carpenter.......	Little finger fractured ..	A piece of iron fell on little finger.
170	Dec. 1	Bell Mine.........	Bell Asbestos Mines....	Israel Bilodeau.....	53	Carpenter.......	Contusion to right leg ..	Belt slipped off a pulley and hit his leg.

171	Dec. 1	Granite Quarry....	The Laurentian Granite Co., Limited.	Osias Girard.......	40	Labourer.......	Hand bruised..........	Was handling stone to crushers, big stone rolled down from pile and struck his hand.
172	Dec. 1	Jacobs Mines......	Jacobs Asbestos Mining Co.................	Jos. Lessard.......	51	Pit Labourer.....	Left arm broken above elbow.	Some loose rock fell from the edge of the pit striking him on the arm.
173	Dec. 4	Jacobs Mine.......	Jacobs Asbestos Mining Co.	P. Vaillancourt.....	22	Pit Labourer.....	Middle finger of right hand cut and bruised.	His finger was caught in a drill.
174	Dec. 5	British Canadian...	Asbestos Corporation of Canada.	Ludger Labrie.....	..	Labourer........	Two fingers slightly bruised.	While loading a derrick box his fingers were caught between two small pieces of rock.
175	Dec. 9	Jacobs Mine.......	Jacobs Asbestos Mining Co.	J. Bordua.........	58	Pit Labourer.....	Bruise on right foot.	While loading a derrick box he dropped a stone on his foot.
176	Dec. 11	Delson Plant.......	National Brick Co. of Laprairie	A. Metras.........	50	Trackman.......	Toes of right foot crushed	His foot was caught under track rail whilst helping unloading from railroad car.
177	Dec. 14	Jacobs Mine.......	Jacobs Asbestos Mining Co.	Jos. Turgeon.......	24	Pit Labourer.....	Contusion of right knee and left thigh.	Dynamite explosion.
178	Dec. 14	Bell Mine.........	Bell Asbestos Mines....	Antoine Lapointe...	48	Pit Labourer.....	Right heel sprained.....	Foot jammed between two stones.
179	Dec. 14	Bell Mine.........	Bell Asbestos Mines....	Joseph Privereau...	49	Pit Labourer.....	Right ankle badly sprained.	Injured was carrying a tie on his shoulder when he slipped and fell down.
180	Dec. 16	Federal Mine.......	Federal Asbestos Co....	Emile Nadeau.....	20	Miner...........	Cut to the head and fracture of parietal bone.	Caused by a stone which fell from ascending derrick box.
181	Dec. 23	Bell Mine.........	Bell Asbestos Mines....	Pierre Ploudre.....	39	Carpenter.......	Left instep cut with an axe.	Injured dropped his axe on his foot.

GEOLOGY AND MINERAL RESOURCES

ALONG NATIONAL TRANSCONTINENTAL RAILWAY IN THE PROVINCE OF QUEBEC

Geological Reconnaissance between Harvey Junction and Doucet, and along the Canadian Northern Railway from St. Thecle to Rivière à Pierre.

By J. Austen Bancroft.

INTRODUCTION

In reporting to the British Government the results of his explorations during 1859-60 of that broad portion of Canada lying between Lake Superior and the Pacific Ocean, Captain Palliser writes as follows: "As a line of communication with the Red River and the Saskatchewan prairies, the canoe route from Lake Superior to Lake Winnipeg, even if modified and greatly improved by a large outlay of capital, would, I consider, be always too arduous and expensive a route of transport for emigrants and never could be used for the transport of stock, both from the broken nature of the country passed through and also from the very small extent of available pasture. I, therefore, cannot recommend the Imperial Government to countenance or lend support to any scheme for constructing or, it may be said, forcing a thoroughfare by this line of route either by land or water, as there would be no immediate advantage commensurate with the required sacrifice of capital; nor can I advise such heavy expenditure as would necessarily attend the construction of any exclusively British line of road between Canada and Red River settlement. As regards the fitness for settlement of the district traversed by the canoe route, I beg to state that there are only very few and isolated spots where agriculture could be carried on, and that *only by the discovery of mineral wealth would this region be likely to attract settlers.*"[1]

Palliser arrived at this conclusion after traversing that portion of the great Laurentian plateau of Canada that lies between Lake

[1]The Journals, Detailed Reports and Observations Relative to the Exploration of a Portion of British North America," by Captain Palliser, page 6, London, 1863.

Overturned fold in gneissoid granite containing dark ribbon-like bands of amphibolites. One mile and a quarter south of Lac Chat Station, or 97.5 miles west of Quebec bridge.

Superior and Lake Winnipeg. His remarks in this connection show that he was a keen and accurate observer, but he was not endowed with that foresight and courage that characterized the group of men that constructed the Canadian Pacific Railway. His conclusion is of very pointed historical interest when today three competing transcontinental railways traverse the full breadth of this Laurentian plateau, which extends from within a few miles of the St. Lawrence on the east to within a few miles of Winnipeg on the west. Apart from the important exceptions of the "Clay Belt" of northeastern Ontario and northwestern Quebec, the Lake St. John district in Quebec, the eastern and marginal portion of the plateau where it is irregularly embayed by terraced lowlands of sands and clays, and in addition, a few small isolated and very widely scattered areas, his observations concerning agricultural possibilities hold true for the whole of the vast Laurentian plateau. His remarks concerning the attraction of settlers by the discovery of mineral wealth (italicized by the writer) have been corroborated by the development of the mining centres of Sudbury, Colbalt, Porcupine and many other smaller places. Experience has taught that it is useless for prospectors to search for ore deposits within the widespread areas of this plateau that are occupied by gneissoid granites and closely allied rocks. Within that portion of the Laurentian plateau described in the present report they should rather devote their attention to those areas underlain by rocks into which the granitoid rocks are intrusive.

For 1225 miles, the recently completed National Transcontinental Railway passes across the Laurentian plateau. Of this distance 450 miles lie within the Province of Quebec. Within the past few years reconnaissance geological surveys[1] have been made of areas adjacent to this railway—from Okiko, which lies on the boundry line between Ontario and Quebec eastward for 156 miles,

[1] "Geological Reconnaissance Along the Line of the National Transcontinental Railway in Western Quebec," by W. J. Wilson, pp. 56 Geol. Surv. of Canada, Memoir No. 4, 1910.

"Report on the Geology and Mineral Resources of Keekeek and Kewagama Lakes Region," by J. Austen Bancroft. Report on Mining Operations in the Province of Quebec during 1911, pp. 160-207.

"Reports on the Geology and Natural Resources of Portions of the Drainage Basins of the Harricanaw and Nottaway Basins," by J. Austen Bancroft. Report on Mining Operations in the Province of Quebec during 1912, pp. 131-236.

"Kewagama Lake Map-Area, Quebec," by M. E. Wilson, pp. 122 Geol. Surv. of Canada, Memoir No. 39, 1913.

"The Harricanaw Basin, north of the Grand Trunk Pacific Railway, Quebec," by T. L. Tanton. Summ. Repts. of Geol. Surv. of Canada, 1915, pp. 168-170; 1914, pp. 96-98.

to Doucet. Attention has been especially attracted to this northwestern portion of Quebec, because from Nottaway westward the railway passes through the "Clay Belt," where there are very considerable areas of land that are eminently suitable for agriculture and because of its close proximity to a portion of Ontario, within which very valuable mineral discoveries have been made. When it has been prospected as thoroughly as the adjacent areas in Ontario, it is the belief of the writer that some important mining centres will likewise be established in northwestern Quebec.

From Doucet very nearly to the eastern margin of the Laurentian plateau, the country along the railway had not been examined from a geological point of view. With the hope that some areas might be discovered within which it would be advisable for prospectors to concentrate their efforts, Mr. T. C. Denis, Superintendent of Mines in the Province of Quebec, instructed the writer to make a geological reconnaissance of that portion of the railway from Hervey Junction (75.4 miles west of Quebec City) to Doucet, a distance of 275 miles. With the aim of visiting a marble quarry at St. Thècle and also of determining whether there is any extension to the northward of the highly altered sedimentary rocks in Montauban township[1] which include deposits of zinc and lead ores near Notre Dame des Anges, the Canadian Northern Railway was also traversed from St. Thècle to Rivière à Pierre, a distance of 25 miles.

The field work occupied nine weeks—from the middle of July to the latter part of September. Mr. Emile Piché, a graduate of Ecole Polytechnique, Montreal, acted as my assistant. All outcrops of rock in close proximity to the railway were examined, and in some localities traverses were extended for a mile or more from the railway. In only one instance did one of these traverses attain a distance of four miles from the railway.

The map which accompanies this report has been compiled by Mr. A. O. Dufresne, of the Mines Branch, from the following sources: (1) Plans and Surveys by J. O. Lacoursière, for the Department of Lands and Forests, Quebec. (2) Survey of the line of the National Transcontinental Railway by J. M. Roy, for the same department. (3) Map No. 5, Watershed of the river St. Maurice, Department of Lands and Forests.

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[1] "The Geology of Parts of the Township of Montauban and Chavigny and of the Seiginory of Grondines" by J. Austen Bancroft. Report on Mining Operations in the Province of Quebec during 1915, pp. 103-143.

Previous Geological work.—A few quaint references to the geology of a portion of the district, described in the present report, are included in the "Reports of the Commissioners appointed under the Act 9th, George IVth, Chap. 29, for exploring that part of the Province which lies between the Rivers St. Maurice and Ottawa and which still remains waste and uncultivated," that was published at Quebec in 1830. Within this report reference is made to the presence along the St. Maurice River, from La Tuque to Weymontachingue, of rocks of the character of syenite and granite and the frequent occurrence of such minerals as quartz, hornblende, feldspar and mica. After commenting upon the sandy soil and the almost complete absence of "vegetable mould," their conclusion that "an incalculable period will elapse ere the land in this district can be fit to receive the needy settler who depends upon the produce of his land alone for subsistence" is, in my opinion, a comparatively mild mode of stating that in general the district is not suitable for agriculture.

In 1891, Dr. A. P. Low[1] traversed some of the streams and lakes south and east of La Tuque that are now near to, or are crossed by, the National Transcontinental Railway; he also examined the rocks along the Canadian Northern Railway from St. Tite to Rivière à Pierre.

In 1898 Dr. R. W. Ells[2] prepared a report on "The Geology of the Three Rivers Map-Sheet," in which he included a brief though somewhat more complete account of Low's observations. The geological map accompanying Ells' report is on a scale of four miles to the inch and shows the country through which the Transcontinental Railway now passes for about twenty miles north of Hervey Junction. With the exception of two narrow bands of crystalline limestone, on the eastern shore of Lake Mekinac, the map depicts the area, embraced by the present report, as being underlain by "granite and gneiss," no distinction being drawn between gneisses of igneous origin and those developed by the intense metamorphism of stratified rocks.

The geological map of the "Vicinity of the National Transcontinental Railway, Abitibi District, Quebec," which accompanies the report of W. J. Wilson, published by the Geological

[1]Report of the Geol. Surv. of Canada, Vol. V, Part 1, 1890-91, pp. 46AA-47AA.

[2]Report on the Geology of the Three Rivers Map-Sheet," Geol. Surv. of Canada, Vol. XI, 1898, pp. 48J-50J.

Survey in 1910, extends eastward to include Coquar, which is 55 miles east of Doucet. From Doucet to Coquar the railway is shown to be traversing an area occupied by "granites, granite-gneisses, garnetiferous gneisses, etc."

TOPOGRAPHY.

From Hervey Junction westward to Hibbard, a distance of about 150 miles, the scenery is more varied than that of any other portion of the Laurentian plateau along the National Transcontinental Railway. Here, in climbing to the more uniformly high interior parts of the plateau, the railway passes through the broken topography of its eastern border where the lower courses of the rivers and streams have sunk themselves deeply into its surface. It is westward from Hibbard toward Doucet that, from the railway, the true features of this physiographic unit are most readily recognizable. It is a broad undulating lowland from the flat to gently rolling surface of which low rocky hills and ridges rise that seldom reach or exceed 100 feet in elevation above the average level. The level character of the surface is quite independent of the complex variations, both in the structure and in the composition, of the underlying rocks.

From Hervey Junction (583 ft.) to Doucet (1219 ft.) altitudes on the railway vary from a minimum of 507 feet at Fitzpatrick to a maximum of 1,493 feet above sea-level at a point about 5.5 miles west of Coquar station, where the height of land between waters flowing to the St. Lawrence River and to Hudson's Bay is crossed. In the vicinity of the height of land there is a wide area possessing an average elevation of 1400 to 1,500 feet above sea level. For about thirty miles west of the height of land the elevations on the railway are never less than 1,364 feet, but at Doucet, twenty miles farther westward, the average level of the plateau has descended to about 1,200 feet above sea-level.

Eastward from the height of land for seventy-nine miles to Hibbard (1,464 feet) the lowest altitude on the railway is at Clova, which is 1,347 feet above sea-level. Towards its eastern border the surface of the plateau, as represented by the uniform level of the summits of its prominent hill groups, gradually descends to an average elevation of 900 to 1,000 feet. At its immediate margin, where it is embayed and in part overlapped by the terraces of sands

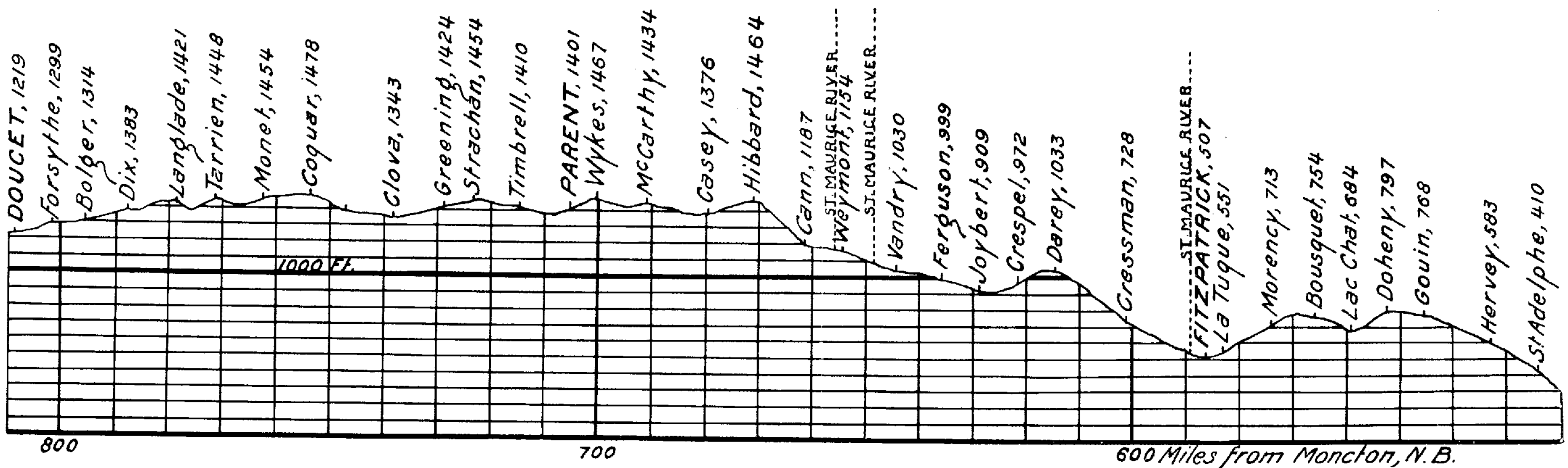

Fig. 1.—Profile of that portion of the National Transcontinental Railway, from Hervey Junction to Doucet. Scales: horizontal, 30 miles = 1 inch; vertical, 1000 feet = 1 inch. (From "Altitudes in Canada" by James White, Commission of Conservation, Ottawa, 1915).

and clays that, rising to a maximum level of about 640 feet above sea-level, border the lowlands of the St. Lawrence River, its hills are variable in altitude, and the characteristics of the plateau are more or less obscured. For example, eastward from Hervey Junction, many of its hills rise as isolated rocky knolls and ridges from the surface of the sandy lowlands.

Thus, if considered as a whole from east to west, the surface of this portion of the Laurentian plateau is gently convex, with a broad flat top. This is well displayed in the profile showing the elevations along this portion of the railway, which has been copied from the profile accompanying "Altitudes in Canada," by Mr. James White, Deputy Head of the Commission of Conservation, Ottawa. Certain broad, shallow depressions within this surface mark the relative positions of the drainage basins of the most important rivers and their tributaries. The most prominent minor irregularities in the profile are due to the crossing of watersheds between tributaries.

From Hervey Junction to Doucet the railway traverses portions of the drainage basins of four rivers—the Batiscan and the St. Maurice Rivers, which are important tributaries of the St. Lawrence; the headwaters of the Gatineau River, which is the most important tributary of the Ottawa, and the Megiskan River, a tributary of the Bell River, which, flowing northward, joins the waters of the Nottaway River that debouches into James Bay. For about 17 miles N.N.W. from Hervey Junction, the railway ascends the valley of the small and turbulent Tawachiche River, a tributary of the Batiscan, and, passing the lakes from which its waters flow, crosses the watershed between the Batiscan and St. Maurice Rivers. Then for 150 miles to about a half a mile east of Wykes Station, the railway is within the drainage basin of the St. Maurice River. From here, for about 30 miles to a point situated three miles west of Strachan Station, the railway traverses the headwaters of the Gatineau River, when, for 32.5 miles, it once more crosses an important southern branch of the headwaters of the St. Maurice River to the height of land, 5.5 miles west of Coquar. From the height of land to Doucet, a distance of about 50 miles, the railway traverses the upper portion of the drainage basin of the Megiskan River.

As is true of other portions of the Laurentian plateau, broad areas in the vicinity of the height of land and local watersheds are here characterized by an abundance of streams that appear to wander more or less aimlessly from lake to lake, and extensive muskegs or swamps are of frequent occurrence. In descending from the higher portion of the plateau towards its eastern margin, the streams flow with gradually increasing swiftness of current, and the rapids are progressively heavier and more frequent.

The St. Maurice River has its source in a multitude of lakes, connected by a labyrinth of streams with very shallow valleys; towards the eastern margin of the plateau the valley of this river becomes progressively deeper, and, in general, the current is swifter and heavy rapids more numerous. Along portions of its lower course, as from Cressman to below Sterling, it flows in a narrow gorge-like valley, confined between steep, rocky walls, which here and there are bordered by remnants of both sandy and bed-rock terraces. "Its course is broken by a dozen rapids and falls which will be capable of developing 650,000 horse power[1] when the La Loutre dam, about forty miles above Weymontachingue, has been completed.

Much sandy drift was irregularly strewn over the surface of the country by the Pleistocene ice sheet, which also imparted flowing, rounded contours to the rocky hills and ridges. The cover of drift is especially heavy on the higher central and more uniformly level portions of the plateau, and toward the east in the more deeply incised portions of the valleys. Much of this drift has been accumulated into knolls, hills and ridges, either isolated or in irregular groups, that frequently are 25 feet and occasionally 60 or 70 feet in height; these include excellent examples of kames, drumlins and eskers. The eskers are especially well represented by the long winding sandy ridges, such as occur a half a mile east of Hibbard and also in the vicinity of Oscalanea Station. Between Parent and Doucet, a distance of 102.5 miles, the total length of the cuttings through sandy glacial drift, often filled with boulders, certainly exceeds eight miles and probably equals ten or twelve miles. But the major portion of the drift was spread out to form gently rolling sandy flats frequently strewn with boulders. A large proportion of these flats are underlain by stratified sands which undoubtedly were deposited in shallow lakes that developed during the last recession of the ice-sheet.

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[1] Water Powers of the Province of Quebec, by F. T. Kaelin, Dominion Water Power Branch of the Department of the Interior, Ottawa, 1915.

As watersheds were laid bare by the receding ice, tributary streams flowing northerly developed extensive shallow lakes in front of the ice-sheet. For example, the wide sandy flat extending southward from that portion of the railway from a short distance west of Crespel nearly to Belgo would appear to have been the site of an irregular shallow englacial lake.

Near the height of land a large proportion of the great area now occupied by the maze of lakes and streams that form the headwaters of the St. Maurice River must have been occupied by an extremely irregular shallow lake, studded with numerous islands that extended southward across the N. T. R., in the vicinity of Oscalanea and Clova. This englacial lake must have been much more extensive than the great artificial lake that will be formed upon the completion of the La Loutre dam across the St. Maurice at a point about forty miles above Weymontachingue. This dam, which is now being constructed to regulate the flow of the St. Maurice River, will develop an irregular lake, enclosing a multitude of islands, and occupying an area of several hundred square miles.

To the north of the height of land some of the lakes of today were more extensive during the recession of the ice-sheet than at the present time. This is very evident in the case of Lake Durand, between Dix and Bolger Stations. It, moreover, seems probable that, at least in its earlier stages, shores of the great shallow sheet of water known as the historical glacial lake Ojibbeway, within which the clays and sands of the "Clay Belt" of Northern Ontario and Northwestern Quebec were deposited, extended to a short distance eastward of Doucet.

With the minor exception of the slopes of some of the hills between Hervey Junction and La Tuque, that are irregularly cloaked with boulder clay, and certain stratified clays that are exposed in some of the bays on Lake Mekinac, the soils of this whole area may be classified either as stratified sands or unstratified sandy till, which is very frequently filled with abundant pebbles and boulders. Many of the cuttings along the railway display stratified sands resting upon the unstratified sandy till. As a result of these sandy soils the waters of the rivers, streams and lakes are extremely clear, and sandy beaches are of frequent occurrence on the shores of the larger lakes. These are features that strongly contrast this area with the "Clay Belt" to the west, where the waters of the rivers and lakes are ever more or less turbid and the shores of lakes and banks of rivers are almost universally muddy, with the exception of occasional stretches where bed-rock is exposed.

During at least the latter portion of the Glacial Period, the Laurentian plateau stood much lower than it does today, and coincident with the retreat of the ice-sheet an irregular arm of the Atlantic Ocean, known as the Champlain Sea, extended far up the valleys of the St. Lawrence, Ottawa and Richelieu rivers. In several localities within the St. Lawrence and Ottawa valleys, beaches representing the upper limit of submergence are known to possess elevations of from 600 to 690 feet above the present sea-level. The terraced sands and clays of the St. Lawrence lowlands were deposited within the waters of this Champlain Sea, whose northern and western shores were formed by the eastern margin of the Laurentian plateau. That these shores were rugged, deeply indented, and fringed with a multitude of islands is well exemplified in the vicinity of Hervey Junction, which is situated towards the western margin of the broad terraces of sandy land which, toward the eastward, surround many isolated rocky knolls and ridges of the Laurentian plateau and to the westward extend far up many of its valleys. Northwest of Hervey Junction, Big Long and Mekinac Lakes were then a true fiord. Both of these lakes are long, narrow and deep. Confined between steep, rounded walls of gneissoid rocks that rise to 400 and 500 feet above its waters, Lake Mekinac is known to be 265 feet in depth. On the southern shore of Rhéaule Cove, a deep bay on the eastern shore of this lake, about half a mile north of the mouth of the Brochet River, laminated blue clays are overlain by stratified sands. The lower courses of both the Brochet River and of its tributary, the Milieu River, must have also been submerged by the Champlain Sea. Where crossed by the railway on a trestle about 170 feet high, the Milieu River at low water is 542 feet above sea level; from this trestle one can distinguish at least four different sets of terraces within the valley of this stream.

Terraces of sands and gravel likewise extend up the narrowing valley of the Tawachiche River for seven to eight miles from Hervey Junction and to an altitude of about 640 feet.

But the valley of the St. Maurice River must have been one of the deepest of the irregular indentations in this shore line of the Champlain Sea. The town of La Tuque, situated on this river and about 103 miles from its mouth, stands at an altitude of 551 feet, on the western margin of a broad sandy terrace, which must be at least 140 feet above the river. About a half a mile west of the N.T.R. there is a remnant of a still higher terrace. For thirteen or fourteen miles above Fitzpatrick, remnants of terraces of sands and gravels are present to an altitude of between 650 and 700 feet. From eight to twelve miles above Fitzpatrick, viz., from a few miles below Stirling nearly to Cressman, along which stretch the valley of the St. Maurice is narrow and in places gorge-like, there are also a few remnants of bed-rock terraces which are now 30 feet or more above the river, showing that here the river is now entrenching itself within portions of an early valley floor.

As the land emerged and the sea withdrew to its present position, the St. Maurice and its lower tributaries and other rivers flowing from the eastern margin of the Laurentian plateau gradually entrenched themselves within the stratified sands that had been deposited in the lower courses of their valleys during the Champlain submergence.

GENERAL GEOLOGY

A description of the bed-rock geology of the country examined must consist of an explanation of the following three statements:—(1) The area is underlain by plutonic igneous rocks that are almost universally gneissoid and, locally, include immense number of narrow bands or shreds of intensely metamorphosed sedimentary rocks that belong to the Grenville Series. (2) All of the rocks comprising this complex area are intersected by small bodies and dykes of granite and a large number of irregular pegmatite dykes that ramify in all directions and frequently are reticulating. (3) In a few widely separated localities, dark, massive, fine to medium-grained dykes traverse all other rock-types.

The most important events in the geological history of this area may be briefly summarized as follows:—In early Pre-Cambrian times, an extremely thick series of sedimentary rocks, including sandstones, limestones, shales, etc., and known as the Grenville Series were deposited within an area whose boundaries have not as yet been delineated, but which is now known to have covered this area in common with at least the south-eastern and eastern portions of the Laurentian plateau, including Eastern Labrador and Baffin Land. There then followed a period of mountain-building, accompanied by incursions of deep-seated magmas, which invaded Grenville series that were then being folded. These magmas, which are today represented by the Laurentian granites and allied rocks that are almost universally gneissoid, completely obliterated the original floor on which these early sediments had accumulated. Injecting the sedimentary rocks parallel to their stratification and in *lit par lit* fashion, they rifted off great roof curtains which were progressively reduced into a multitude of long narrow bands that were being more and more widely separated by the advancing magma or magmas. The term magma has been used in the plural because it is plain that in certain places the banded character of the gneiss has been produced by a series of successive parallel injections, with almost, if not quite, the same direction of foliation; belonging to one and the same period of magmatic advance, the earliest of these possessed the composition of gabbro-diorites, diorites or granodiorites, and those that followed were marked by increasingly acid compositions. While these events were in progress, the orogenic forces were locally kneading the still plastic magmas, laden with their metamorphosed and more or less absorbed bands of sedimentary rocks, into complex folds which, in some instances are of the overturned type. (See Plate III). When eventually the magmas came to rest, the lower contact of the remaining portion of the uplifted and folded Grenville Series that then formed a roof over them must have been very much tattered and torn. From this roof there descended long streamers or shreds of the Grenville Series which, decreasing in number and in average width with depth, gradually merged into the magmas that were digesting them. During the later stages of the consolidation of the magmas, the deeper and yet molten portions of the batholithic mass were injecting the cooled peripheral parts and the tattered roof with pegmatite dykes that locally are very abundant and in many places occur in the form of an anastomosing network of dykes and dykelets.

It is possible that ever since the great period of mountain building that was attended by the widespread intrusion of the Laurentian gneisses and granites, this area has been subjected to the continuous action of processes of erosion. No remnants of sedimentary rocks of more recent age than the Grenville Series occur within the area. It is only when one considers the thick sedimentary formations of post-Grenville age and the unconformities that separate them, that are present in many other portions of the Laurentian plateau, that one comes to a realization of the great magnitude of the Pre-Cambrian post-Grenville time interval.

During this enormous interval of later Pre-Cambrian time, it is certain that at times the area experienced crustal disturbances. This is evidenced by the intrusion of a few bodies of granite and syenite, which are later than the older and more universally foliated Laurentian gneisses and granites. At a very much later date, probably in Keweenawan time, the area was traversed by a few dark massive fine-grained dykes of diabase, augite porphyrite, etc. It is impossible to say whether the faults that are present are predominantly of Pre-Cambrian or of later age.

But apart from the structural relations of the Laurentian gneisses and their included narrow and widely separated bands of altered Grenville sediments, no other feature of the geology of the area is more impressive than the great depth to which erosion has been carried. Especially is this true when one appreciates the fact that the area had been profoundly eroded prior to the deposition of the Upper Cambrian and Ordovician rocks that on the eastern margin of the Laurentian plateau are resting upon a rolling surface of Laurentian granites and gneisses, which include similar narrow metamorphosed bands of the Grenville Series. Therefore, even prior to Upper Cambrian time, the removal of a blanket of rocks, many thousands of feet in thickness, had exposed the deep roots of the mountains of early Pre-Cambrian time and had developed a gently rolling hummocky surface.

Today, not a fragment of Palæozoic rocks can be found within the area. Yet from analogy with other portions of the Laurentian plateau, it may be that in early Palæozoic times (possibly from Upper Cambrian to Lower Devonian) this area was covered by a sea within which sandstones, limestones and shales were deposited in a sequence of formations similar to that of the Palæozoic rocks beneath the St. Lawrence lowlands. If so, not only have these early Palæozoic rocks been completely removed by erosion during the late Palæozoic, the Mesozoic and the Tertiary, but the Pre-Cambrian rocks were also eroded to still greater depths than they had been previously to the Upper Cambrian.

Every feature of the geology of the area testifies to the great depths to which erosion has been carried. The reservoirs within which the Laurentian granites and gneisses cooled have been truncated to a depth where only the tattered and more or less absorbed ends of a few of the longest curtains or *lits* of the Grenville Series extended. The mineralogical character of the narrow bands of altered sediments, viz., the paragneisses, which are frequently garnetiferous and sillimanite-bearing, the amphibolites and the crystalline limestones, which are filled with scapolite, diopside, hornblende, chondrodite, sphene, spinel, etc., also relate the same story. So likewise, the composition of the myriads of pegmatite dykes, which were not observed to contain other minerals than quartz, feldspars, biotite, hornblende, magnetite, and in a few instances, garnet tourmaline, muscovite and pyrite, shows that they cooled at great depths. A large number of these pegmatite dykes carry abundant grains and crystals of magnetite, some of which are occasionally several inches across.

During the Pleistocene period, the great ice-sheet that moved outwards in all directions from the central portion of the Labrador peninsula passed across this area. For a discussion of the events that then followed the reader is referred to the preceding pages of this report, where the topography of the area is described, and to later pages under the heading of the Quaternary.

The writer is fully convinced that when the geology of the Laurentian plateau is known in greater detail, it will be possible to delineate the positions formerly occupied by the mountain chains of Pre-Cambrian times. Even now it is possible to draw significant comparisons. For example, that portion of north-western Quebec to the west of the Bell River, and extending for 30 miles or more on either side of the N.T.R., was never so mountainous as the area described in this report.

GRENVILLE SERIES.

Only shreds of this great series of early Pre-Cambrian sedimentary rocks are present within the area. In many places the igneous gneisses enclose narrow elongated bands, varying from a few inches to a few hundred yards in width of what are obviously sedimentary rocks, which, through processes of contact metamorphism, have been converted into many varieties of paragneisses, amphibolites and crystalline limestones. Invariably, these bands are many times longer than broad; both along the strike and dip they are frequently much folded and crenulated, but in general they are conformable to the foliation of the intrusive gneisses. Every gradation may be observed from the broader bands or narrow areas of sedimentary rocks that have been more or less injected, in *lit par lit* fashion, by the igneous gneisses, to isolated zones within the latter, where vast numbers of very narrow, parallel ribbons or slat-like bands of the altered sediments are present.

Even in the broader bands these rocks have been so intensely metamorphosed that it is only possible to designate in a general way the original character of the sedimentary rocks from which they have been derived. A vast majority of the narrow bands have been so modified by the magmas that in their varied compositions they have so converged toward igneous rock-types that it is now impossible to decipher what they were originally. For example, one finds gradation from sillimanite-gneisses that plainly developed through the metamorphism of arenaceous and argillaceous sediments, to granites that contain a very few scattered crystals of sillimanite. It is impossible to distinguish certain amphibolites, whose field relations suggest that they were derived from the extreme metamorphism of limestones or shales, from those whose field relations show that they originated from a gabbro-diorite or diorite.

In traversing a portion of the area where the igneous gneiss is uniform in character, the approach to an enclosed band of altered sedimentary rocks is usually prefaced by the appearance of an increasing number of narrow parallel streaks or ribbons, rich in hornblende and biotite, within the igneous gneiss; or the latter rock may become smouched because of the irregular distribution of an increased amount of the ferromagnesian minerals. The contacts between the narrow dark bands and the igneous gneiss gradually become sharper, the bands become broader and eventually one passes into definite paragneisses, etc., which, in some instances, are not only banded but retain evidence of their original bedding. It is plain that within the area described in the present report, the igneous gneisses have absorbed much of the Grenville Series.

The original stratification of the sediments from which they have been developed has been especially well preserved in paragneisses of an exceptionally quartzose composition, such as those exposed in a cutting on the N. T. R., about 19.5 miles above Fitzpatrick. In such instances the foliation is parallel to the stratification and since, where less quartzose paragneisses, amphibolites and bands of crystalline limestone are intercalated between the paragneisses, they appear to be interstratified with the latter, it seems certain that, in general, the foliation that has been induced in these sedimentary rocks has been developed parallel to their bedding.

Remnants of the crystalline limestones of the Grenville Series were observed as far westward as the southwestern corner of Suzor township, which is from three to four miles north of the N. T. R. at a point about thirteen miles east of Parent Station. Bands of sillimanite-bearing paragneisses were, however, observed at intervals within the igneous gneisses westward to a mile and a third west of Dix Station, or, 19 miles east of Doucet Station.

Paragneisses.—The paragneisses are intensely metamorphosed arenaceous and argillaceous rocks. These sedimentary rocks have been completely recrystallized and, in some instances, have had their original compositions modified by additions from the magmas that cooled to form the igneous gneisses. Usually, the colour of the paragneisses varies from a light to a very dark gray, according to the relative amounts of biotite or hornblende present. Occasionally they are rusty in appearance because of the oxidation of disseminated grains of pyrite.

Frequently they are characterized by the presence of two or more of the following minerals: sillimanite, garnet, graphite, small grains and crystals of rutile and a few minute rounded crystals of zircon; but, in many instances, garnet may be the only one of these minerals present, and in composition the rock is a biotite-gneiss, which under the microscope can not be distinguished from some of the garnetiferous igneous gneisses. In certain types even garnet is absent, and in composition the paragneiss then becomes similar to a biotite-granite.

Brief descriptions of some of the most interesting of the paragneisses will now be given:—

The high and steep eastern shore of Lake Mekinac affords an exceptional opportunity for the study of the relations between the bands of the altered Grenville Series and the Laurentian gneissoid granites. For at least four miles south of the Brochet River the gneissoid granite in several places contains bands that vary from a a few inches to about one hundred yards in width, of graphite—or sillimanite-bearing garnetiferous paragneisses, amphibolites and a few narrow bands of impure crystalline limestone. A few hundred yards south of the entrance to the bay which approximately marks the middle of the length of the lake, there are some paragneisses which include one band, four feet in width, containing abundant small flakes of graphite, and another band eight feet wide, filled with garnets that lie in a matrix, which is chiefly composed of quartz and matted fibres of sillimanite. Under the microscope the latter rock is found to also contain a few grains of orthoclase, a few flakes of biotite, abundant small grains of black iron ore, a little graphite and a considerable number of minute rounded crystals of zircon. The garnets exhibit a marked tendency to lenticular forms or augen, which are partially enwrapped by the long, narrow crystals of sillimanite.

About a hundred yards west of Morency Station there is a typical occurrence of paragneisses, some bands of which are very rusty because of the weathering of included grains of pyrite. Especially striking in appearance is a dark band within these gneisses which contains a multitude of augen of dark-red garnets, the majority of which are from one-third to one-half an inch across. The garnets comprise slightly less than one-third of the volume of the rock, and in thin sections, under the microscope, it is found that the matrix within which they are distributed is composed of a mosaic of quartz and orthoclase enclosing abundant prismatic crystals of sillimanite, numerous flakes of biotite and a less amount of muscovite, small grains of black iron ore and of pyrite, a few short prismatic crystals of rutile and a very few minute rounded grains of zircon. Here also the augen of garnet are partially enwrapped by the long and narrow crystals of sillimanite. The quartz and orthoclase are present in approximately equal amounts. Some of the quartz grains are penetrated by a vast number of hair-like crystals of rutile.

About a mile west of the trestle across the Vermilion River and 19.5 miles west of Fitzpatrick, paragneisses, with a maximum width of 125 yards, are enclosed in gneissoid granite and are cut by numerous stringers of pink granite. Two or three narrow bands, three to four inches in width, are composed chiefly of scapolite, diopside and a little calcite, and are honeycombed because, under conditions of weathering, much of the calcite has been removed in solution; undoubtedly they are all that now remains of former beds of limestone. There is also a heavy band of paragneiss, about 20 feet thick, which is remarkably uniform in grain and in its light, yellowish-gray colour. It possesses a distinct stratification, parallel to which the foliation has developed. One of its planes of foliation was observed to be coated with an almost continuous film of graphite. Garnets of light red colour and less than a tenth of an inch across are very abundantly scattered through the rock. In addition, small needle-like crystals of sillimanite, minute flakes of graphite and biotite and grains of quartz and orthoclase are discernible with the naked eye. In thin sections, under the microscope, the rock is found to also contain a few small grains of black iron ore, some of which are partially altered to leucoxene, a few minute crystals and grains of rutile, and a very few rounded grains of zircon. There is slightly more quartz than orthoclase present.

In a cutting on the railway, two and a third miles west of Parent, a heavy band of a gneiss which is identical in appearance with the type last described is intercalated between paragneisses of dark gray colour. In thin section under the microscope, the orthoclase in this rock displays microperthitic structure, and in a few cases this mineral is intergrown with quartz.

In the rock cuts on the railway at either end of the bridge crossing the St. Maurice River, *four miles west of Vandry and 61.8 miles west of Fitzpatrick*, gneissoid quartz-augite-syenite of dark green colour includes numerous parallel narrow bands of dark gray paragneisses striking N.-S., and dipping 60° E., that are especially rich in graphite. In the cutting just east of the southern end of the bridge, an irregular band of crystalline limestone with a maximum width of two feet is intercalated between bands of these paragneisses. The limestone is coarsely crystalline and contains numerous small rounded grains of diopside and a few flakes of graphite. Adjacent to these altered sedimentary rocks, the augite-syenite also contains abundant flakes of graphite which are distributed parallel to the foliation. In some narrow bands of the paragneisses, the graphite comprises from five to ten per cent of the rock, and in a few places very thin seams, less than an eighth of an inch in width, of practically pure graphite trend parallel to the foliation for distances of a few inches or feet. Two specimens of these graphite-bearing paragneisses were examined in thin sections under the microscope. One of these specimens was found to be more than half composed of a mosaic of quartz grains, in addition to which, grains of turbid orthoclase, a few flakes of biotite, abundant flakes of graphite, numerous minute prismatic crystals of apatite, small grains of pyrite and black iron ore and a very few minute rounded zircon grains, are present. The other specimen was found to be more than three-fourths composed of plagioclase feldspar, with small amounts of quartz, biotite, graphite, apatite and pyrite.

In the southwestern corner of Suzor township, immediately east of the watershed between the Gatineau and the St. Maurice Rivers and from three to four miles north of the railway, there is a small elongated area about 400 yards in length and with a maximum width of about 200 feet, underlain by heavy bands of crystalline limestones. Locally, at the eastern margin of this area bands of amphibolite and of a uniform greenish-gray medium-grained rock lie between the limestones and intrusive gneissoid granite. Under the microscope this fresh greenish-gray rock was found to be composed chiefly of quartz with abundant grains of orthoclase, less plagioclase, numerous grains of an exceptionally deep green and strongly pleochroic pyroxene, a few flakes of biotite and muscovite, and a few grains of sphene, pyrite, black iron ore and apatite. A small amount of calcite is interstitially distributed within this rock.

About two and a half miles east of Parent and towards the western end of a long cutting through paragneisses injected *lit par lit* by gneissoid granite, there are some heavy bands of a light gray gneiss which, were it not for the abundant visible needles of sillimanite that lie with their longest axes parallel to the foliation, might easily be mistaken for a normal biotite-granite-gneiss. It is the best example of an extremely fresh coarse-grained sillimanite gneiss that the writer has encountered in the Grenville Series (see Plate IV. B.). Under the microscope it is found to be composed of quartz, orthoclase, sillimanite, numerous grains of garnet, flakes of biotite, a few grains of black iron ore and of pyrrhotite and a very few rounded grains and crystals of zircon. Paragneisses which are very similar to this type but contain less sillimanite, a little more biotite and a few grains of plagioclase are exposed in a cutting on the railway about two miles east of Coquar, or 41.75 miles west of Parent.

Very nearly a mile east of Clova Station, or 40.8 miles west of Parent, there is an exposure, about 20 feet in width of a very dark gray paragneiss exceptionally rich in quartz. Under the microscope, it is found to be composed chiefly of a mosaic of coarse grains of quartz, together with a few grains of orthoclase and plagioclase, some dark green hornblende, a little augite, considerable garnet of dark red colour, a few small grains of black iron ore and pyrite, an occasional needle-like crystal of apatite and a few minute grains of rutile.

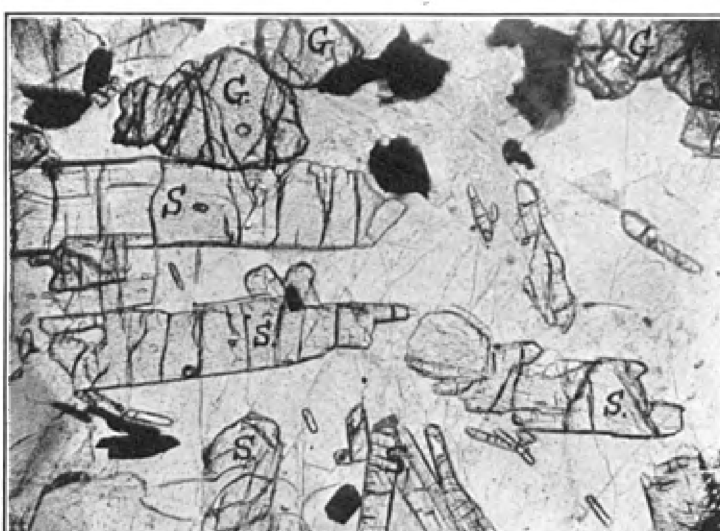
A few yards to the east of the seventieth mile-post west of Parent, or about three and a quarter miles east of Langlade Station, there is a heavy series of bands of dark reddish-gray paragneisses which are exceptionally rich in dark-red garnets, very many of which are a third of an inch across. In some bands of the gneiss the garnets comprise slightly more than one half of the volume of the rock. Under the microscope the garnets are found to be lying in a matrix composed chiefly of quartz, with numerous flakes of biotite and a few grains of orthoclase, sphene, black iron ore and pyrite.

About a mile and a third west of Dix Station, or about nineteen miles east of Doucet, a cutting about 50 yards in length passes through paragneisses, which, with the exception of certain quartzose bands rich in garnets, fracture so readily along their planes of foliation that they might approximately be called schists. All of these rocks are very rich in garnets, a few individual crystals of this mineral being an inch and a quarter across. A specimen from one of the dark-gray bands was examined under the microscope and was found to consist chiefly of quartz, with much biotite, a few garnets, abundant crystals of sillimanite, a few grains of orthoclase and a few minute crystals of apatite.

The quartzose bands intercalated between these paragneisses in this locality are recrystallized quartzites. Under the microscope they were found to be composed of a mosaic of coarse grains of quartz, within which there are distributed numerous large and small grains of light-red garnet, a very few small flakes of biotite, a few small and widely scattered grains of black iron ore and an occasional minute rounded crystal of zircon.

Crystalline Limestones.—Narrow bands of crystalline limestones were observed in only fifteen of the large number of rock-cuts on the National Transcontinental Railway. One of these occurrences is situated about half way between the stations of Brochet and Julien, or 31.25 miles west of Hervey Junction. Between the eighteenth and sixty-second mile-posts west of Fitzpatrick, or from the first rock-cut east of the trestle across the Vermilion River to the eastern end of the bridge across the St. Maurice, four miles west of Vandry Station, crystalline limestones are exposed in thirteen rock-cuts. Two and one-third miles west of

A.—Photomicrograph of impure limestone from a point about halfway between Brochet and Julien Station. Note the deformation of the twinning planes within the grains of calcite. D.—Grains of diopside.



B.—Photomicrograph of light gray sillimanite-gneiss, from a cutting on the N.T.R., 2½ miles east of Parent. S.—Sillimanite; G.—Garnet.

Cann, or 76.7 miles west of Fitzpatrick, for a width of fifty feet, numerous bands of limestone are intercalated between amphibolites.

In these localities the individual bands or beds of limestone do not exceed ten feet in thickness, and usually they lie between bands of paragneisses and amphibolites. In a few places, however, isolated bands or streaks of crystalline limestone, roughly lenticular in form and only a few inches in width and a few feet or yards in length, lie within the igneous gneisses, parallel to the foliation. Examples of the latter mode of occurrence are to be seen toward the western end of a cutting on the railway 1.9 miles west of Vermilion, towards the eastern end of another cutting just about half way between Vermilion and Darey, and at the western end of a cutting two-thirds of a mile west of Darey.

Both along the dip and strike the limestone bands pinch and swell, and frequently they are much contorted. Where long exposed to the atmosphere, the limestones weather with characteristic fluted or cavernous surfaces. All of the limestones are coarsely crystalline; usually their colour is white, but sometimes different shades of pink. Frequently, they contain more or less magnesia.

In all of the localities where they were observed on the railway the limestones are very impure, for they contain myriads of rounded grains of two or more of the following minerals that have been developed under the influences of contact metamorphism—diopside, scapolite, phlogopite, hornblende, sphene, chondrodite, olivine (forsterite), spinel, quartz, plagioclase and a few scales of graphite. Because of the removal of the calcite or dolomite by the solvent action of rain water, the grains of these minerals stand out in relief on weathered surfaces. In a few localities, the limestones also contain disseminated grains of pyrite, the oxidation of which imparts a rusty appearance to some exposures of these rocks.

Some of the more interesting occurrences within these limestones of the minerals mentioned in the preceding paragraph will now be briefly described:—

About half way between Brochet and Julien Stations, or 31.25 miles "west" of Hervey Junction, an irregular band of limestone, with a maximum width of six inches, and some dark bands of paragneisses, lie within reddish gneissoid granite. The limestone is dull-white in colour, and contains numerous fresh grains of diopside and considerable chlorite that has been derived from the partial decomposition of small flakes of phlogopite. In thin section under the microscope the individuals of calcite are seen to have developed twinning and exhibit strong strain shadows; many of the grains of calcite are bent and twisted (see Plate IV. A.). In several other localities the calcite within these limestones were observed to have developed similar phenomena because of the pressure to which they have been subjected.

Two and a half miles west of Vermilion, or about 220 yards to the west of mile-post 21, west of Fitzpatrick, the railway for nearly 100 yards passes through crystalline limestones interbanded with amphibolites and paragneisses, striking N. 20° W. and dipping about 25° toward the northeast. One of these limestone bands was found to contain numerous grains of diopside, scapolite, flakes of phlogopite and disseminated grains of pyrite.

About 400 yards east of Vandry Station and on the south side of the railway, a distorted band of amphibolites and impure, coarsely crystalline limestones, about 20 feet in width and striking N. 28° W. with a dip that varies from 40° to 60° toward the southwest, is enclosed within green gneissoid syenite. Here the crystalline limestones contain rounded grains of chondrodite, olivine (forsterite), hornblende, small flakes of phlogopite, numerous minute grains and octahedral crystals of a very dark blue to black spinel, and a few grains of scapolite. The chondrodite is honey-yellow to brownish-yellow, the hornblende is transparent and of a dark bottle-green colour and the forsterite is transparent and colourless. Under the microscope, the chondrodite is strongly pleochroic, from a deep yellow to nearly colourless; the hornblende is pale-green; the spinels are of a uniform bluish-green colour. The grains of forsterite are traversed by irregular cracks, which in some instances are lined with serpentine. Both the chondrodite and the forsterite gelatinize when boiled in hydrochloric acid.

The forsterite occurs as almost perfectly spherical grains, which are transparent and colourless and possess a high index of refraction. The majority of these grains are less than a twentieth of an inch in diameter, and none of them were observed to exceed a tenth of an inch across. Under the microscope they display the characteristic high index of refraction, and are optically positive; some of the grains exhibit distinct cleavage, while all of them are traversed by irregular cracks. Upon ignition the forsterite assumes a bright, brick-red colour.

Since, in so far as can be ascertained, this is the first occurrence of an olivine to be reported from crystalline limestone in Canada, some fragments of the limestone were placed in dilute hydrochloric acid, and the magnesian-bearing calcite being dissolved, the fresh grains of forsterite were then picked out from the chondrodite, phlogopite, hornblende, spinel and scapolite. Its specific gravity was found to be 3.283. This mineral was then analyzed by Professor N. N. Evans of McGill University. The determinations were made in duplicate and the results were as follows:—

	I	II	Mean Ratio
$Si\ O_2$	41.27	41.31	.688
$Al_2\ O_3$	trace	trace	
$Fe\ O$	7.57	7.42	.104
$Ca\ O$	.....	.....	
$Mg\ O$	51.43	51.48	1.286
	100.27	100.21	

The ratio of $Mg\ O + Fe\ O : Si\ O_2$ is almost exactly 2:1, the theoretical ratio for the olivine group. The ratio of $Mg\ O:FeO$ is 12.4:1, which is a little low for forsterite. Nevertheless, because its content of iron is very low when compared with that of ordinary olivines, and because of its absence of colour, this mineral has been here referred to forsterite rather than to chrysolite or olivine.

About two-thirds of a mile west of Darcy Station, within a zone about twenty feet in width, the gneissoid granite encloses a few narrow irregular bands of crystalline limestone of salmon pink colour, one of which attains a maximum width of eighteen inches. A specimen of this limestone was found to contain abundant grains of scapolite, pyroxene, sphene and quartz. In thin section under the microscope the pyroxene is of an exceptionally deep-green colour.

About half a mile east of Windigo, or about 250 yards east of mile-post 43 west of Fitzpatrick, there is a rock-cut, within which, for a distance of about 100 yards, bands of amphibolites, crystalline limestones and paragneisses alternate with bands of gneissoid granite, the whole series striking N. and S., with very nearly vertical dip. They are traversed by irregular pegmatite dykes, some of which contain abundant crystals of magnetite, up to half an inch across, and by a quartz diorite dyke which, because of the peculiar distribution of its hornblende content, has an uncommon spotted appearance. Here all of the bands of limestone are narrow and very impure. Some of them have been converted to a pale, grayish-green granular rock, more than eighty percent. of the volume of which is scapolite, while the remainder is composed of grains of diopside, sphene, black iron ore, pyrite and calcite.

When the geology of the areas adjacent to that portion of the National Transcontinental Railway, described in this report, is examined in detail, very many narrow areas of metamorphosed sedimentary rocks not shown on the accompanying map will undoubtedly be found, some of which will include bands of limestone. In support of this statement it is only necessary to point out that on the eastern shore of Lake Mekinac, within four miles south of the mouth of the Brochet River, bands of impure crystalline limestone, intercalated between paragneisses and amphibolites, are enclosed within gneissoid granite. None of the limestone bands exceed ten or twelve feet in thickness, and all of them are laden with grains of diopside, scapolite, phlogopite, etc. So, likewise, about two miles south of Flamand Station, on the western slope of a ridge a few hundred yards east of the Flamand River, a few parallel bands of similarly impure crystalline limestone, each less than two feet in thickness, and a few ribbon-like inclusions of amphibolite, lie within gray-gneissoid granite.

In fact, the largest areas of Grenville limestones observed within the area are situated about 110 miles apart in a straight line, and in each instance are about four miles from the nearest railroad. These areas are of very small dimensions when compared with the extensive development of Grenville limestones that characterizes certain of the more southern portions of the Laurentian plateau.[1] One of these areas, 350 yards in length and with a maximum width of about 200 feet, is situated on lots 200, 201 and 202, Range B North, Price Seigniory, in the Parish of St. Thècle, about four miles northwest of St. Thècle Station, which is on the Canadian Northern Railway, 3.7 miles south of Hervey Junction. The other, with an area about 400 yards in length and a maximum width of about 200 feet, lies in the southwestern corner of Suzor Township, about five miles northwest of McCarthy Station on the National Transcontinental Railway, which is 107.5 miles west of La Tuque.

[1] "Geology of the Haliburton and Bancroft Areas, Province of Ontario," by F. D. Adams and A. E. Barlow, Geol. Surv. of Can., Memoir No. 6, 1910.

A.—Cliffs of shattered Laurentian gneiss, north of trestle crossing valley of Milieu River.

B.—Bands of amphibolite in gneissoid granites. About one mile north of the trestle crossing the valley of Milieu River.

In both of these localities white, coarsely crystalline limestones occur in heavy bands or beds, and in places are bordered by paragneisses and amphibolites. In each instance these areas represent irregular remnants of *lits* or curtains of highly altered Grenville Series that have been torn and embayed by the gneissoid granites that completely surround them and in some places penetrate them in the form of dyke-like bodies that usually trend parallel to the strike.

During 1911 and 1912 an attempt was made to develop a marble quarry on lot 202 of the St. Thècle occurrence, where massive bands of coarsely crystalline limestones are quite free from joint planes and, striking a few degrees west of north, dip at low angles towards the east. The marble varies from white to salmon pink in colour, but unfortunately, from a commercial point of view, its value as a decorative stone is nullified because of the presence of numerous inclusions of dark-grey to black biotite-paragneiss and amphibolite that are so dispersed that it is impossible to quarry blocks which will not contain them. Even the purest of the marble contains a few scattered grains of white to transparent diopside, which appears in relief on weathered surfaces. In a few places within this area the marble also contains some small flakes of phlogopite.

The limestones shown on the map in the southwestern corner of Suzor township, and about three miles north of the National Transcontinental Railway is the most western occurrence of Grenville limestones observed within the area. Striking N. to S., they dip at variable angles toward the east. White to salmon pink in colour, the limestones are irregularly and coarsely crystalline. In places, bands or beds attain a width of three or four yards and are so coarse in grain that single cleavage faces of calcite are frequently more than an inch across. Many of these cleavage faces display the intimate intergrowth of two calcite individuals. It is only in a very few places that these heavy bands of limestone are not laden with abundantly disseminated grains of diopside, scapolite, phlogopite, etc. One band was observed to locally contain a very few widely scattered small grains of chalcopyrite and bornite and an occasional flake of graphite.

Amphibolites.—Where paragneisses and crystalline limestones of the Grenville Series occur, they are almost invariably interbanded with dark basic rocks, which are chiefly composed of green hornblende and plagioclase. In all varieties of this rock-type, two or more of the following minerals are also present—biotite, augite, orthoclase, garnet, quartz, sphene, pyrite, black iron ore, apatite, calcite, epidote, zoisite and chlorite.

Many of these amphibolites are fine to medium-grained, and in a few places they are so intensely foliated that they might be appropriately referred to as hornblende-schists; but there is every gradation to the other extreme where the rock shows but faint foliation and possesses the texture of a coarse-grained diorite. Field relations frequently display gradations from both impure limestones and paragneisses to amphibolites; moreover, the manner in which thin bands of amphibolite lie between paragneisses that originally were highly quartzose sandstones suggests that in large part the amphibolites were developed from shales. It is plain that a large proportion of the amphibolites have been derived from the metamorphism of limestones, shales and calcareous sandstones.

Both in hand specimens and under the microscope it seems impossible to distinguish the amphibolites that have originated from these sedimentary rocks from those that have been developed by the recrystallization while under pressure of certain basic igneous rocks, such as diorites, diabase and gabbro-diorites. In a few places these basic igneous rocks occur as dykes cutting the gneissoid granites, as, for example, the irregularly branching dyke of amphibolite that is exposed in the first cutting north of the trestle crossing the valley of the Milieu River. In other places certain diorites and gabbro-diorites that have been more or less changed to coarser-grained amphibolites, appear to represent an early phase of the old igneous gneisses, which during later stages of the same period of rising magmas were injected parallel to their foliation by more acidic phases of the magma.

IGNEOUS ROCKS.

Plutonic Types.—Probably more than ninety-nine per cent of the lands immediately adjacent to the N. T. R., between Hervey Junction and Doucet, are underlain by plutonic rock-types which are almost universally gneissoid and which in many places, parallel to their foliation, include abundant narrow bands, usually less than two or three feet in width, of highly altered rocks of the Grenville

Series. By far the major part of these plutonic rocks vary in composition from granites to granodiorites, but, in addition, syenites, diorites and gabbro-diorites are of quite frequent occurrence. In a very few localities they possess the composition of gabbros, pyroxenites and hornblendites.

Very detailed geological work would have to be performed to delineate the distribution of these various plutonic rock-types upon a map. Likewise a map would have to be prepared on a large scale to show the many localities where these gneissoid plutonic rocks include narrow, parallel, ribbon-like bands of the altered and partially absorbed rocks of the Grenville Series.

For the most part, the plutonic rocks are of Laurentian age, or, in other words, they belong to the most ancient period of rising magmas that has been revealed by geological studies of the "Canadian Shield." In many localities it is plain that during this early period of rising magmas, there were successive intrusions. Peripheral portions of the batholiths which had crystallized during a lull in the upward advance of the magmas were ruptured and injected *lit par lit* by later advances of the more deeply seated and increasingly more acidic portions of the batholiths that had remained molten. Many of the dioritic phases of these gneissoid rocks apparently owe their composition to the absorption of rocks belonging to the Grenville Series. But many of the most basic phases, such as some of the diorites, gabbro-diorites, gabbros and the pyroxenites, which usually occupy comparatively small areas, are apparently forerunners of the more acidic magmas which have later injected them.

One of the most common of these early basic phases is a very dark greenish-gray garnetiferous gabbro-diorite, such as, for example, is exposed in cuttings a little less than a half a mile west of mile-post 19 west of Fitzpatrick, and about a quarter of a mile west of mile-post 68 west of Parent. In places this rock is massive; in others it is foliated; in some localities it gradually passes into the gneissoid granites; in others the granite intrudes it with sharply defined contacts, and frequently in *lit par lit* fashion. Under the microscope this rock is found to be more than one-half composed of a pale-green augite, and of hornblende which is strongly pleochroic, ranging from a dark to a pale yellowish-green; the remainder of the rock consists of very fresh plagioclase, numerous irregular grains of garnet, and a few grains of quartz, black iron ore, pyrite and apatite

About two and a quarter miles east of Wykes a cutting on the railway, 20 feet in depth, passes through a pyroxenite which is intensely foliated and which under the microscope is found to be composed of coarse grains of augite, abundant flakes of biotite, a very few small grains of plagioclase, a few grains of apatite and magnetite.

In the ditch north of the railway track, one-fifth of a mile west of mile-post 51 west of Parent, or 3.4 miles west of Clova, there is an isolated exposure of an interesting pyroxenite that is composed of hypersthene, a pale green hornblende and numerous small, irregular grains of pleonaste and magnetite.

In places the old Laurentian gneisses have been invaded by bodies of granites and syenites of later Pre-Cambrian age. The extensive batholith of granite in the vicinity of Rivière à Pierre, on the Canadian Northern Railway, and the batholith of quartz-augite syenite, which is crossed between Vandry and Weymont stations on the National Transcontinental Railway, constitute the most extensive areas observed to be underlain by more recent plutonic rocks. In many places, too, especially between Fitzpatrick and Parent, the older igneous gneisses are cut by small irregular bodies and dykes of pink to reddish medium-grained granites, within which, in places, the gneissoid structure is absent. Because of the successive intrusions that occurred during the Laurentian period of rising magmas, it is often difficult to determine whether some of the gneissoid granites belong to the Laurentian or are of a more recent Pre-Cambrian age.

The greenish quartz-augite syenite which forms the rugged groups of hills between Vandry and Weymont, on the N.T.R., encloses numerous bands of both the older Laurentian gneisses and of the altered sedimentary rocks of the Grenville Series. For the most part this syenite is gneissoid, but in places no traces of foliation are present. Quartz is often present in such amounts that the rock would appropriately be called an augite-granite. Thin sections of specimens from three localities between Vandry and the bridge across the St. Maurice River were found to contain orthoclase, augite, dark-green hornblende, quartz, garnet, biotite, a few disseminated grains of black iron ore and a few minute crystals of apatite and zircon. These minerals have been mentioned in the order of their relative abundance; in one of the thin sections a few grains of secondary epidote, calcite, leucoxene and a little chlorite were present. In part, the orthoclase exhibits microperthitic structure. When polished, the massive phases of this greenish syenite should afford a desirable ornamental stone.

To illustrate the petrographical character of the small irregular bodies and dykes of pink to reddish-medium-grained granites that have been mentioned above as penetrating the Laurentian gneisses, specimens from a railway cutting about a half a mile east of Cressman, and from another cutting two and a quarter miles west of Darey were examined in thin sections under the microscope. In the first locality the pink granite was found to be composed of microcline, orthoclase, quartz, plagioclase, a few small flakes of biotite, numerous small grains of magnetite and a few minute crystals of zircon; the microcline comprises more than one-half of the volume of the rock. The granite from the second locality differed only in that it contained less microcline and a very few ragged grains of calcite, leucoxene, chlorite and pyrite.

Pegmatite Dykes and Quartz Veins.—Both the igneous gneisses and the intensely metamorphosed remnants of the Grenville Series are traversed by a swarm of pegmatite dykes and a few irregular stringers and veins of quartz. A few of these dykes trend parallel to the foliation of the rocks which they traverse; but in general they ramify in all directions, often forming a reticulating network of dykes. They vary from less than an inch to several yards in width; the vast majority of them are less than a foot wide. Individual dykes pinch and swell in an extremely irregular manner. Usually they are red or pink, and less frequently white in colour.

They are chiefly composed of varying proportions of quartz and feldspar. Biotite is the most common dark constituent, but hornblende individuals, up to several inches in length and one or two inches thick, are of frequent occurrence. Muscovite is quite often present, but in no instance were flakes of this mineral observed to be more than two inches across. The presence of black tourmaline was noted in not more than six or seven of the vast number of these dykes that were examined. Some of the dykes are characterized by the presence of myriads of red garnets. In many instances, grains and crystals, up to three inches across, of magnetite are very abundant. In a few cases, pyrite is present both in the form of abundantly disseminated grains and crystals.

Orthoclase is by far the most common feldspar, though plagioclase, varying in composition from albite to oligoclase, is often present. Some of the pegmatite dykes associated with the body of augite-syenite that the N. T. R. crosses between Vandry and Weymont are chiefly composed of orthoclase, with small amounts of biotite, hornblende and magnetite.

On the south side of the railway and a few hundred yards east of Clova Station, a pegmatite dyke, rich in garnets, possesses a striking banded appearance because of the alignment of the garnets parallel to its walls. This dyke also contains orthoclase, plagioclase, quartz, a few flakes of muscovite, and a small amount of calcite which has been derived from the incipient alteration of the plagioclase.

Three and a quarter miles west of Clova, certain stringers of pegmatite, up to three inches in width, are also of special interest because they are almost entirely composed of flakes of biotite, some of which are an inch and a half across.

In a cutting on the railway, four and three-quarter miles west of Langlade, or about 40 yards east of milepost 77 west of Parent, there is an irregular pegmatite vein or dyke, with a maximum width of a foot and a half, which is composed of quartz, orthoclase, muscovite, an iron-bearing carbonate, tourmaline, black iron ore, pyrite and small grains and crystals of rutile. This is an interesting assemblage of minerals that has been developed under conditions of aqueo-igneous fusion. In places, small crystals of quartz, feldspar and the iron-bearing carbonate project into drusy cavities within the dyke. The orthoclase is quite vitreous in appearance and its cleavage faces are less than an inch across. The quartz sometimes possesses idiomorphic outlines. The tourmaline occurs in long bayonet-shaped crystals which occasionally are three inches in length and a quarter of an inch in thickness; a few of the tourmaline crystals are fractured and pulled apart. The flakes of muscovite do not exceed a half an inch across; many of them possess characteristic crystals outlines and frequently their cleavage faces display the six-rayed cracks, known as "percussion-figures" which may be produced artificially by striking a cleavage plate of mica with a sharp-pointed instrument. The majority of the grains and crystals of rutile are of microscopic dimensions, but a few of them are just discernible to the naked eye.

Very few of the quartz veins observed within this area, exceed a few inches in width. Small, irregular veinlets of quartz are of quite frequent occurrence. Every gradation may be observed from a pegmatite dyke rich in feldspar to one which is composed of quartz. It is plain that at least the majority of the quartz veins in the area represent the acidic extreme of the magmatic solutions from which the pegmatic dykes were developed.

Dark Dykes.—In a very few widely separated localities, dark dykes traverse the gneissoid rocks and comprise the youngest rocks within the area. A few of these dykes, which have been subjected to such pressures that they have been foliated, probably were injected soon after the consolidation of the older intrusive gneisses and granites and their associated pegmatite dykes. Other dark dykes which are massive, remarkably fresh and allied in composition to the diabase group of rocks are believed to be very much younger, though probably of late Pre-Cambrian age.

An example of a dyke which, according to these criteria, belongs to the older series traverses gneissoid granite at the northern end of the first rock-cut north of the long trestle that spans the valley of the Milieu River. Here, an irregular medium-grained dark dyke, with a maximum width of ten feet sends forth numerous branches and stringers and contains many inclusions of the gneissoid granite which it intersects. The marked tendency to schistosity in the dyke trends parallel to the foliation of the gneiss which here strikes approximately N–S. When examined in this section under the microscope this dyke was found to be an amphibolite composed of the following minerals which are mentioned in the order of their relative abundance:—feldspar, common green hornblende, small flakes of biotite, numerous small grains of sphene and quartz, widely scattered irregular grains of black iron ore and pyrite and a few minute crystals of apatite. Although only a few of the feldspar grains show polysynthetic twinning, it is certain that some, and probable that all, belong to one of the plagioclases. Sphene is exceptionally abundant in the form of small irregular grains that seldom show a tendency to assume the characteristic wedge-shaped outlines.

Another dark dyke which is even more intensely foliated than the one just described, is exposed on the face of the cliff which borders the south side of the railway about a half a mile eastward from the trestle crossing the Vermilion River. With a maximum width of eight inches and dipping gently to the eastward, it appears as a dark gray streak which contrasts sharply with the light gray gneissoid granite that forms the cliff. In thin section under the microscope, a typical specimen of this dyke was found to consist of orthoclase, plagioclase, a few grains of quartz, much biotite, numerous grains of black iron ore, myriads of minute crystals of apatite and a few widely scattered small grains of sphene. The feldspar forms more than one-half of the volume of the rock while approximately one-fourth of its volume is biotite. The rock possesses an equigranular mosaic structure that suggests it was recrystallized at the time that its foliation was developed.

In a cutting, 6.1 miles north of Hervey Junction, a vertical black dyke of the diabase family, varying from three to ten inches in width, and striking N 10° E traverses gneissoid granite.

Of special interest are the dyke occurrences about midway between the stations of Brochet and Julien which are 1.74 miles apart. Here in two cuttings, the gneissoid rocks, for an irregular width of a few feet in each instance, have been shattered, brecciated and injected by a very dense black magma. This basic magma must have been extremely fluid and intruded with explosive violence, for the gneisses are traversed by a multitude of minute reticulating threads and dykelets, none of which exceed three or four inches in width. These occurrences are approximately 190 yards apart, the more northerly one being the more striking because the fragments of gneiss lying within the black matrix are there of a bright red colour. Under the microscope, it was found that these dykes are composed of a few minute lath-like microlites of plagioclase and dust-like particles of black iron ore disseminated through a matrix of dark glass. It also includes abundant angular particles of feldspar and quartz that were derived from the trituration of the component minerals of the gneiss. The glassy matrix exhibits a marked flow structure and contains a few minute spherical bodies now composed of calcite and chlorite, which probably were originally minute spherulites of feldspar.

One mile west of Belgo Station, two dykes, a few yards apart and two feet and three feet in width, respectively, are roughly parallel to each other and strike N 40° W. Cutting uniform gneissoid granite, one of them is vertical while the other dips 75° toward the northeast. Massive, extremely fresh, medium-grained and of a dark gray colour, these dykes are composed of plagioclase, augite, a little green hornblende and biotite, abundant small grains of black iron ore, a few grains of pyrite and a few minute crystals of apatite. The augite occurs as small rounded grains which are approximately equal in size. A few of the plagioclase individuals assume the dimensions of small phenocrysts. These dykes belong to the group of augite-porphyrites.

A dyke, fifteen inches wide, which is identical in appearance with these augite porphyrites near Belgo, is exposed in a cutting about three and a quarter miles east of Weymont Station. Westward from this point no more massive fine-to-medium-grained dark dykes were observed.

Two miles east of Bolger Station and fifty or sixty yards north of the track there is a low ridge, about two hundred yards long and twenty feet high and with a maximum width of nearly one hundred yards that rises from low sandy land strewn with boulders. The ridge is composed of a uniform porphyritic gabbro of fairly coarse grain which shows no trace of foliation, and which probably is intrusive into the gneissoid rocks. Rounded phenocrysts of diallage, frequently one-fifth of an inch across, are abundantly scattered through a matrix of plagioclase. In thin section under the microscope, it was found that each of the irregularly rounded grains of diallage is almost invariably surrounded by a narrow rim or corona that is usually composed of green hornblende with a few flakes of biotite and irregular grains of black iron ore; occasionally these rims are chiefly composed of a garnet which is colourless under the microscope and frequently includes numerous small particles of hornblende, biotite and black iron ore. Along the inner margins of these rims the hornblende is frequently very intimately intergrown with the diallage in a manner which suggests that the former is sending a multitude of sharply defined rootlets into the latter. About one-half of the volume of the rock is plagioclase which in common with the diallage is frequently filled with extremely minute, dark inclusions. The minerals composing this rock are remarkably fresh and the coronas appear to have been developed during the crystallization of the magma.

STRUCTURES.

As has been previously stated, the plutonic rocks and the altered sedimentary rocks of the Grenville Series are almost universally foliated. From the accompanying maps, it will be observed that for long stretches the strike of the foliation is approximately parallel to the general direction of the N. T. R. Thus from Hervey Junction to La Tuque, the prevailing strike of the foliation is N. N. W., which dips toward the southeast, while from Oscalanea to Doucet the strike, though locally variable, is more closely east to west with dips toward the south.

In very many localities, the foliation of the gneisses is intensely folded and crenulated. In some places, the gneisses have been cast into folds of quite large dimensions. Exceptional opportunities to observe folding within the Laurentian gneisses are afforded by the precipitous rocky shores of Lake Mekinac, and the long, steep side-cutting that on the east side of the N. T. R., extends northward for somewhat more than a mile from the trestle across the valley of the Milieu River. In these localities, the folding has in places been of the close and overturned type (see Plate III). It is the belief of the writer that a detailed study of areas between Hervey Junction and La Tuque would reveal the presence of overfolding on a large scale.

That the area is traversed by faults is shown by the frequent presence of shear zones and slickensided surfaces. These are of especially frequent occurrence in many of the railway cuttings between Milieu and La Tuque. The steep escarpment which for long distances within this stretch lies close to the eastward of the railway is probably a topographic expression of faults which strike approximately north and south.

QUATERNARY.

The glacial features that were imparted to the topography of this area have been described on preceding pages of this report under the heading of Topography.

The following observations show the true directions in which the Labrador ice-sheet was moving as it crossed the line now occupied by the National Transcontinental Railway between Hervey Junction and Doucet:—

Mileage from Quebec	Nearest Station	Glacial striæ
80.3	4.1 miles E of Gouin	S 30°E
117.8	4.7 " W " Morency	S 3°W
119.4	3.3 " E " La Tuque	S 26°E
183.2	0.5 " E " Vandry	S 16°E
206.2	4.5 " E " Hibbard	S 26°E
215.0	4.2 " W " Hibbard	S 16°E
216.8	2.8 " E " Casey	S 23°E
229.8	0.4 " E " McCarthy	S 26°E
234.4	4.2 " W " McCarthy	S 27°E
239.1	0.4 " E " Wykes	S 5°E
240.2	0.7 " W " Wykes	S 5°W
245.4	0.7 " W " Parent	S 2°W
271.0	2.9 " W " Greening	S 2°E
283.7	1.7 " E " Clova	S 1°W
286.2	0.2 " W " Clova	S 6°W
300.4	0.6 " E " Monet	S 16°W
309.0	1.4 " E " Tarrien	S 26°W
312.9	2.5 " W " Tarrien	S 26°W
314.7	3.2 " E " Langlade	S 28°W
323.7	3.2 " E " Dix	S 46°W
324.2	2.7 " E " Dix	S 26°W

In general, to the east of the low divide between McCarthy and Wykes that separates the drainage basin of the upper Gatineau from that of the St. Maurice River, the ice-sheet was moving toward the east of south; westward from Wykes towards Doucet, its movement was more and more to the west of south. Local variations in the direction of the movement of the ice were caused by local topographic features; in some instances, it is plain that minor irregularities in the topography sufficed to deflect the lowest portion of the ice-sheet.

Although universally vigorous, glacial erosion here appears to have been somewhat less intense on the more uniformly high portions of the plateau than towards its eastern margin where it is more deeply dissected by valleys. On the higher portions of the plateau, from Hibbard westward to Doucet, features that pertain to the accumulation of glacial debris are more prominent than those that directly concern glacial erosion. In several of the rock-cuts between Parent and Forsythe Stations, a distance of 95.93 miles within which elevations vary from 1299 to 1478 feet above sea-level, small irregular patches or narrow bands of the gneissoid rocks are decomposed to depths of from a few inches to twelve or fifteen feet. Within six miles eastward from Monet these irregular patches and streaks or pockets of decayed gneissoid rocks are displayed in at least five rock-cuts. Here, glacial erosion has not been sufficiently intense to grind down the bed-rock to such a depth as to completely remove the products of pre-glacial weathering.

The vast majority of the boulders and pebbles both within the glacial drift and distributed upon the surface of the country are composed of different varieties of igneous gneisses, of which gneissoid granite is the predominating type. In some localities, the drift also contains numerous boulders of the paragneisses, amphibolites and a few fragments of the limestones of the Grenville Series. On the N. T. R., from three to four miles east of Flamand, boulders of the Grenville Series are quite abundant in the drift, although no outcrops of these rocks were observed in the vicinity.

In a shallow cutting about two and threequarter miles west of Monet, or about 75 yards east of mile-post 59 west of Parent, a boulder of massive coarse conglomerate, about 3 feet across, lies on the north side of the track. The conglomerate contains rounded pebbles of granite and of various types of Keewatin greenstone. Westward from this cutting to Doucet, a very few boulders of different varieties of Keewatin greenstones occasionally are present in the drift.

ECONOMIC GEOLOGY.

Along the National Transcontinental Railway, from Hervey Junction to Doucet, no ore deposits of value have been found, and judging from the geological character of the country immediately adjacent to the railway, it does not seem probable that this portion of the Laurentian plateau will become celebrated for its mineral wealth. It is certain that more than ninety-five per cent, and probably more than ninety-nine per cent of the lands close to the railway are underlain by gneissoid igneous rocks, chiefly granites and granodiorites. Elsewhere within the Laurentian plateau, rocks of this character have not yielded workable deposits of those minerals from which the metals are economically derived.

It is possible that some valuable mineral deposits may be discovered within some of the remnants of the altered sedimentary rocks of the Grenville Series, or within the igneous gneisses immediately in contact with such remnants. As has been pointed out, the Grenville Series here occurs in the form of comparatively narrow elongated bands of paragneisses, crystalline limestones and amphibolites which are enclosed within the igneous gneisses. It is certain that in addition to the areas of the Grenville Series shown on the accompanying map, many others will be discovered at varying distances from the railway; those who travel within this region should upon finding such areas prospect them carefully. But, considering the area as a whole, it is not a propitious field for the prospector who at present would spend his time more profitably in devoting his attention to that portion of northwestern Quebec on either side of the N. T. R., and westward from the Bell River, where formations favorable to the occurrence of ore deposits are known to occupy large areas.

On the Canadian Northern Railway, about a mile and a half north of east from Rousseau's Mill, and a few hundred yards beyond the rapids in the Batiscan River where, flowing from the north, this stream turns sharply toward the west, there is a cutting, eight or nine feet deep, in gneissoid granodiorite containing numerous ribbon-like inclusions of amphibolite and one narrow irregular band, two or three inches wide, of coarsely crystalline calcite. Immediately beyond this, for about 500 yards, the railway crosses an area of amphibolites which, parallel to their foliation, in a few places enclose similar narrow streaks of calcite. In places, these amphibolites contain disseminated grains of pyrite and pyrrhotite and, in consequence, are very rusty on weathered surfaces. Although locally much contorted, their general strike is N. to S., and their dip varies from 35° to 80° toward the east. This band of altered sedimentary rocks of the Grenville Series should be prospected very carefully with the hope of finding zinc and lead deposits similar to those at Notre Dame de Anges.[1] It seems probable that to the southward these amphibolites are connected with the broad band of Grenville Series that passes through the village of Notre Dame des Anges.

Gold and Copper.—During the past summer, Messrs. Clouthier and Lavoie of Manouan staked the small area of crystalline limestones in the southwestern corner of Suzor township. A little more than a mile westward from McCarthy Station, which is situated 107.5 miles west of La Tuque, a small creek flowing through a swamp, enters the northern shore of this lake. From here, a canoe route, broken by two portages, one of which is a few hundred yards and the other about a half a mile in length, extends northward to a group of small lakes, known as the Lacs Truchon. About four miles from the railway, a small stream enters the western shore of the third lake encountered on this route, and a few hundred yards up this stream, where it forks with a northerly branch extending to a small lake, these mineral claims are situated.

On both sides of this stream, the land is low, yet in a few places along the stream and especially on its northern branch and the southern shore of the small lake, bands of crystalline limestones of white to salmon pink colour are exposed, which strike N to S and dip at variable angles toward the east. Closer examination shows that a small irregular area, about 400 yards in length and with a maximum width of about 200 feet, is underlain by heavy bands of limestone associated with which are narrow bands of amphibolites and paragneisses. Gneissoid granites completely surround these altered sedimentary rocks, which are also traversed parallel to their strike by irregular dyke-like bodies of the granite. The limestones are irregularly and coarsely crystalline. Only portions

[1] See "Report on the Geology of Parts of the Townships of Montauban and Chavigny and of the Seigniory of Grondines, including a description of the Zinc and Lead deposits in the vicinity of Notre Dame des Anges, Portneuf county" by J. Austen Bancroft. Report on Mining Operations in the Province of Quebec during the year 1915, pp. 103-143, with a geological map.

of some of the bands or beds of limestones are free from abundantly disseminated grains of diopside, scapolite, and phlogopite. In places the limestones carry a few widely scattered grains of pyrite and it was this mineral which was mistaken for gold by those that staked the property. With the aid of dynamite, a few shallow openings have been made in the limestones. In one of these openings, on the western side of the brook, impure limestone contains occasional flakes of graphite and a very few particles of copper pyrites and bornite. On the eastern side of the brook, an opening has been made at a junction between bands of coarsely crystalline limestone and amphibolite. In part, the amphibolite is quite heavily impregnated with pyrite. An assay of some fragments of this pyritiferous amphibolite did not yield a trace of gold.

Towards the northern end of the first rock-cut north of the long trestle across the Milieu River, and about 24 miles "west" of Hervey Junction, banded granitoid gneisses are traversed by an irregularly branching dark fine-grained dyke which under the influence of pressure has been converted into an amphibolite. The gneiss here contains a few scattered grains of pyrite and an occasional grain of copper pyrites. During the construction of the railway, prospecting operations were responsible for an irregular excavation in the western wall of the cutting. The occurrence is of no economic importance.

Magnetite.—In many localities, the pegmatite or very coarse-grained granite, dykes carry abundant grains and crystals of magnetite, some of which occasionally are two to three inches across. Good examples of dykes of this character occur in a deep cutting on the N. T. R., about one mile and three quarters east of Crespel Station. Although a source of small specimens of this iron ore, none of these dykes can be considered as a possible economic source of iron.

About one mile and three-quarters west of Cann Station, dark gray gneissoid hornblende-granite includes a dark band of paragneisses, seven or eight feet in width, which carries about 30 per cent of magnetite. In addition to the magnetite, when examined under the microscope, this paragneiss was found to contain much plagioclase, a little orthoclase, numerous flakes of biotite, and a few small grains of quartz and calcite. Although specimens may be collected which are slightly more than half composed of magnetite, the occurrence is not of commercial importance.

There is, however, the possibility that commercially valuable deposits of magnetite may be found in some of the bands of altered sedimentary rocks in the area. There is also the possibility that bodies of magnetite, developed through processes of magmatic differentiation, may be discovered within the large intrusive mass of augite-syenite that forms the prominent hills on either side of the St. Maurice River from a short distance east of Vandry Station westward nearly to Weymont Station.

Graphite.—In several localities, disseminated flakes of graphite occur within the paragneisses. In rock-cuts at either end of the bridge that spans the St. Maurice River four miles west of Vandry, a band of altered sediments, enclosed within quartz-augite-syenite, contains disseminated flakes of graphite, and in a very few places, planes of foliation within these rocks are heavily coated with graphite. For many yards on either side of the altered sediments the gneissoid syenite and some of its pegmatite dykes also contain numerous flakes of graphite. Although no locality was observed where graphite occurs in sufficient amount to be of economic importance, geological conditions suggest that valuable deposits of this mineral may be found within some of the bands of altered sedimentary rocks.

Feldspar and Mica.—Dykes of pegmatite or coarse-grained granite are very numerous within this area and many of them contain a high percentage of orthoclase feldspar. Although no pegmatite dykes were observed which would constitute workable deposits of feldspar it is to be expected that some dykes of large proportions will be discovered from which this mineral may be economically derived.

The white mica, muscovite, is present within very few of the pegmatite dykes; in no locality, were the flakes of this mineral observed to exceed two inches across. In many localities, small flakes of phlogopite, or amber mica, were observed within the bands of crystalline limestones. It may be that economic deposits of this mineral will be found in association with some of the altered limestones.

Garnet.—Bands of gneiss containing abundant garnets are of frequent occurrence within this area. In only one locality, viz., in a shallow cutting on the railway, three and a quarter miles east of Langlade Station, or about sixty yards east of the seventieth mile post west of Parent, were the gneisses sufficiently garnetiferous to suggest that they might be exploited as an economic source of garnet to be used as an abrasive. Here, a band of dark gneiss, exposed for a width of several yards is exceptionally rich in red garnets very many of which are a third of an inch across. The garnets comprise from one-fourth to slightly more than one-half of the volume of the rock. In thin section under the microscope, the garnets in this paragneiss are found to be lying in a matrix composed chiefly of grains of quartz, with numerous flakes of biotite and a few grains of orthoclase, sphene, black iron ore and pyrite.

Marble and Limestone.—The distribution of crystalline limestones within this area has been discussed on earlier pages of this report. None of the known occurrences will yield commercial grades of marble.

During 1911 and 1912, La Compagnie de Marbre du Canada Ltée., opened a marble quarry on lot 202, Range B North, Price Seigniory, in the Parish of St. Thècle, about four miles northwest of St. Thècle Station which is on the Canadian Northern Railway and 3.7 miles south of Hervey Junction. Here there is a series of heavy bands of crystalline limestones, intercalated between which are certain narrow bands of micaceous paragneisses and amphibolites. These altered sedimentary rocks extend across lots 200, 201 and 202 with a length of 350 yards and a maximum width of apparently 200 feet. Striking a few degrees west of north and dipping at angles of from 20° to 50° toward the northeast, they are completely surrounded by gneissoid granite which in places penetrates them in the form of irregular bodies that usually trend parallel to the strike.

On lot 202, where crystalline limestones are quite free from cracks and joint planes, an opening 51 feet x 33 feet was made to a maximum depth of about 12 feet. A large mill was erected and machinery installed for cutting and polishing the marble; during the winter of 1915, the roof of this building collapsed. The limestone varies from white to salmon pink in colour, and is somewhat too coarse in grain to afford a good quality of marble. Unfortunately, too, from a commercial point of view its value as a decorative stone is nullified because under the influence of pressure some of the intercalated bands of amphibolite have been so kneaded into the marble that they appear as inclusions,dark gray to black in colour, which are so dispersed that it is impossible to quarry blocks which will be free from them. Even what appears to be the purest marble contains a few scattered grains of white to colourless diopside which appears in relief on weathered surfaces.

In the report on "The Limestones of the Province of Quebec," by Howells Fréchette of the Mines Branch, Ottawa, an analys sample, which "is representative of the clean marble" from the St. Thècle quarry is given as follows:—

Insoluble Mineral Matter	5.40
Ferric Oxide	.19
Alumina	.13
Calcium carbonate (*a*)	91.29
Magnesium carbonate (*b*)	3.11
(*a*) Equivalent to lime	53.20
(*b*) Equivalent to magnesia	1.34

With the exception of the marble from this locality, the known limestones along the N. T. R., are too impure to be suitable for the manufacture of a good quality of lime.

Building Stones.—For complete descriptions of the excellent varieties of granite that are quarried in the vicinity of Rivière à Pierre, the reader is referred to Volume III of the "Report on the Building and Ornamental Stones of Canada," by W. A. Parks, Ph.D., which has recently been published by the Mines Branch, Ottawa. Situated 56.5 miles from Quebec city, at the junction between the Canadian Northern and the Quebec and Lake St. John Railways, the most of the granite from the quarries at Rivière à Pierre has been marketed in Quebec where it has been used for architectural purposes, for curb stones, and in the construction of the piers of the Quebec Bridge. The church at St. Thècle is built of a gray variety of granite from Rivière à Pierre.

Between Vandry and Weymont on the National Transcontinental Railway, there are some favourable localities where quarries could be opened up in a massive syenite of a rich dark green colour. When polished, this syenite should be suitable for ornamental purposes.

ALPHABETICAL INDEX