View looking westward from rocky knob, on lot 25, range X, Grenville township, showing the Laurenti

PLATE I.

e Laurentian topography of the district, the southern portion of Harrington flat, Rouge river, and the Bell power plant.

View loo, Grenville township, showin

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Magnesite Deposits of Grenville District, Argenteuil County, Quebec

BY

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CHAPTER I.

INTRODUCTION.

GENERAL STATEMENT.

As a consequence of the present war the supplies of numerous mineral materials formerly imported into Canada and United States from abroad have been partly or completely cut off and for this reason special attention has been directed to the investigation of deposits of these minerals occurring on this continent. Among the minerals of this class one of the most important is the magnesium carbonate, magnesite, the world's supply of which was formerly derived almost entirely from deposits in Austria-Hungary and Greece. The restricted importation of this material, especially during a period of unprecedented activity in the metallurgical industries, has brought about a complete transformation in the market conditions in America for magnesite.

The almost complete dependence of the American consumer on foreign sources of supply of magnesite prior to the war and the readjustment which is now taking place is indicated by the statistics of importation and domestic production in the table on pages 12 and 16. In 1913, the year preceding the outbreak of war, 172,591 short tons of calcined magnesite and 22,872 tons of crude magnesite were consumed in United States, of which (only 9,632 tons of crude) less than 3 per cent was produced at home; whereas in 1915 the total consumption of magnesite in United States was 26,574 short tons of calcined and 80,267 short tons of crude, of which approximately 23 per cent was domestic production. Likewise, the production of magnesite in Canada increased from 515 tons valued at $3,335 in 1913 to 55,413 tons having a value of $563,829 in 1916.

Up to the present time (March, 1917) the increase in the domestic production in North America has been derived almost entirely from Canadian deposits situated a few miles north of Ottawa river in the Grenville district, Quebec, and from scattered occurrences in the state of California in United States. Though the Canadian magnesite contains more lime than the California magnesite and in that respect is of inferior quality, in every other respect it has many advantages over the California product. Some of the most important of these advantages are the following:

(1) The Canadian deposits individually are much more extensive and easier to work than those in California.

(2) The California deposits taken as a whole are so limited in extent that even if worked to full capacity they could furnish only a small part of the magnesite needed in United States.[1]

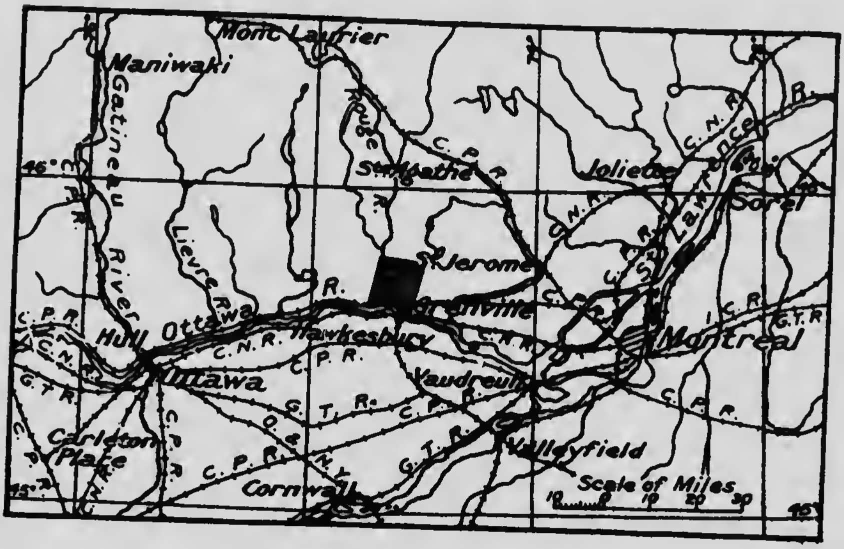

Figure 1. Location of Grenville area.

(3) Since the principal manufactories consuming magnesite are situated in the eastern part of the continent and the freight rate for magnesite between California and points in eastern United States is $10 per ton, the Canadian deposits are much more advantageously situated with respect to the magnesite market.

(4) The cost of labour is considerably higher in California than in Quebec.

(5) At the present time (March, 1917) the actual cost of Canadian magnesite laid down in the principal magnesite markets of United States is from one-half to one-third less than that for California magnesite, a difference which will probably be further increased with the construction of tramways from the Canadian deposits to the railway.

[1] Mineral resources of United States, pt. 2, 1914, p. 571.

In view of the preceding considerations it is probable that for many purposes the California magnesite could not seriously compete with Canadian product in the eastern part of either United States or Canada, provided the Canadian deposits could supply the demand.

This memoir is a brief account of the results of an examination of the Grenville magnesite deposits made by the writer in the course of field work during the field season of 1916; supplemented in the introductory chapter by information of general interest to those engaged in the magnesite mining industry.

MAGNESITE.

Magnesite, the name usually applied to the carbonate of magnesia ($MgCO_3$) as found in nature, is a chemical compound consisting of 47·6 per cent oxide of magnesium, magnesia (MgO), and 52·4 per cent carbon dioxide (CO_2). It is somewhat heavier and harder than calcite, having a specific gravity of 3 to 3·12 and a hardness of 3·5 to 4·5. When free from impurities it has generally a brilliant snow white appearance, but in some of its occurrences, owing to the presence of disseminated impurities, it is yellow brown or grey in colour. Magnesite is almost insoluble in cold hydrochloric acid or sulphuric acid, but dissolves readily with effervescence in warm acids. When subjected to high temperatures a gradual decomposition of the mineral into magnesia and carbon dioxide takes place between temperatures of 300 and 600 degrees centigrade.[1] The resulting magnesia is exceedingly refractory, however, having a fusion point of approximately 2,500 degrees centigrade.[2]

Deposits of magnesite are widely distributed throughout the world and are generally regarded as belonging to one or other of two types, the massive or the crystalline. Massive magnesite, the most common type, is a fine-grained compact variety usually found in veins or masses in serpentine which has resulted from the alteration of magnesia-rich rocks of the peridotite family. To this group belong the Grecian deposits, nearly all the deposits in California, the recently discovered deposits in Bridge River district of British Columbia, and numerous other deposits found in various parts of the world. The crystalline variety of magnesite has been so named because of its coarsely crystalline texture. The principal deposits of this class, so far discovered, are those in Austria-Hungary

[1] Brill, O., Ueber die Dissociation der Karbonate der Erdalkalien und des Magnesiumkarbonate. Zeitschrift f. Anorg. Chem. vol. 45, 1905, pp. 277-292.

Grunberg K., Beitrag. zur Kenntnis der naturlichen kristallistierten Karbonate, des Calciums, Magnesiums, Eisens and Mangans. Zeitschr. f. Anorg. Chem., vol. 80, 1911, p. 337.

[2] 3000° C. according to Moissan.
1910° C. " " Goodwin-Malley, Jour. Am. Electrochemical Soc. vol. 9, 1906, p. 89.
2500° according to O. Ruff, Zeitschr. Anorg. Chem., vol. 82, 1913, p. 373.
2800° " " C. W. Kanolt, Jour. Wash. Acad. Sc., vol. 3, 1913, p. 315.

and the Canadian deposits at Grenville. In both of these localities the magnesite occurs as masses in limestone or associated sediments which have been rendered crystalline by the intense metamorphism to which they have been subjected.

PREPARATION OF MAGNESITE.

Magnesite is usually marketed in one or other of three forms—crude, caustic calcined, and dead burned.

Crude Magnesite. Crude magnesite, as the name implies, is the crude magnesium carbonate as produced at the mine with merely as much of the serpentine, qu tz, dolomite, calcite, or other impurities removed as can be culled away in mining the material or by cobbing.

Caustic Calcined. When crude magnesite is calcined at a red heat (approximately 1,100 degrees centigrade[1]) a product is obtained known as caustic calcined magnesite. This material consists of magnesia (MgO) in which about 2 to 4 per cent of carbon dioxide has been retained. It slakes in contact with water and combines with magnesium chloride to form a hard vitreous material known as oxychloride or Sorel cement.

Dead Burned. If, on the other hand, magnesite is calcined at a white heat (approximately 1,700 degrees centigrade)[2] a product known as dead burned magnesite is obtained. This material contains less than 1 per cent carbon dioxide, is exceedingly refractory, and chemically inert. It does not slake in air or in water, but tends to disintegrate in contact with steam.[3]

USES OF MAGNESITE.

The peculiar and v ried properties of magnesite and its derived products have led to its use in a great variety of industries. Among the most important of these industrial applications are the following:

Refractory Material. Owing to the high fusion point and chemical inertness of the oxide of magnesium, magnesite is one of the principal minerals used in the metallurgical and other industries where highly refractory material is required. For this purpose dead burned magnesite is generally used either in the form of brick or sand. As brick it is used for lining open-hearth steel furnaces, welding, heating, and melting furnaces, copper converters, electrical furnaces, reverberatories, settlers, ar rnaces for refining lead. In the crushed form, it is used for lining ottoms of open-hearth furnaces, for lining rotary kilns, and in making cibles and cupels. Caustic calcined magnesite is also used to a limited

[1] Morganroth, L. C., Bull. A . Min. Eng., No. 93, 1914, p. 2351.
[2] Gowling, W., "The meta the non-ferrous minerals," 1914, p. 10.
[3] According to R. H. Young Metal. and Chem. Eng., vol. 12, 1914, p. 620.

extent as a refractory material in fireproof paint, and in mixtures with crude magnesite and other material in furnace linings.

Recently the Steel Company of Canada, has been using calcined Grenville magnesite mixed with 10 to 40 per cent furnace slag as a lining for open-hearth steel furnaces, with satisfactory results. The chemical composition of the slag is as follows:

Silica	9·81
Alumina	1·78
Oxide of iron	17·29
Lime	51·97
Magnesia	6·74
Phosphoric acid	2·70
Sulphur	0·247
Oxide of manganese	5·67

The manner in which the mixture is prepared and placed in the furnace is as follows:

The crude magnesite as it arrives from the mine is calcined for eight hours in a furnace holding approximately 9 tons of the crude material, about 3 tons of coal being consumed in this operation. The calcined magnesite is then broken down with hammers to fragments one-half inch or less in diameter and mixed with the crushed slag in proportions ranging from 15 to 40 per cent slag and 85 to 60 per cent magnesite.

When a furnace is to be lined it is heated to a temperature above the melting point of the slag (2,700 degrees to 2,800 degrees Fahrenheit), and small charges of the mixture of slag and partially calcined magnesite are thrown in and spread out uniformly over the furnace bottom at intervals of 15 minutes. In this manner the lining is built up on the furnace bottom to the depth required. If carefully laid and intimately mixed this bottom will last for a considerable length of time without repair, and is equal in every respect to bottoms prepared from Austrian magnesite.

Prior to the present war it was stated by manufacturers of magnesite brick generally that refractory brick could not be manufactured from magnesite containing more than a very small percentage of lime, but the following analysis of a magnesite brick obtained from one of the principal purchasers of Canadian magnesite seems to indicate that such is not the case, and that Grenville magnesite is being used in large proportions, if not entirely, for this purpose.

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	
10·26	6·67	2·98	8·70	71·75	loss on ignition 0·05

It is also reported that a mixture of dead burned Grenville magnesite, caustic calcined Grenville magnesite, and magnesium chloride is now being satisfactorily employed as a furnace lining to replace magnesite brick.[1]

[1] Roast, H. J., "The development of Canadian magnesite," Annual meeting, Can. Min. Inst., 1917.

Oxychloride or Sorel Cement. A mixture of finely ground caustic calcined magnesite and magnesium chloride known as oxychloride or Sorel cement has been used extensively in recent years as sanitary flooring, stucco, artificial marble, tile roofing, and other structural material. The use of magnesite for this purpose is based on the fact that when wet with a solution of magnesium chloride of a certain concentration it sets as a hard vitreous cement. As a flooring, this material when properly mixed and laid is much superior to any other variety of cement. It can be coloured, takes a good polish, is waterproof and fireproof, and does not pulverize to dust. Certain practical difficulties have been encountered, however, in procuring a raw material of uniform quality and in consequence the floors have not always been satisfactory. In practice it is generally customary to add certain materials such as wood, serpentine, talc, ground quartz, asbestos, and other substances to the mixture as filler, the resultant mixture being sold under a great variety of trade names such as artificial marble, asbestolith, asbestos floors, compolite, compostone, kellastone marbeloid, monolith, petrified wood, sanitary floors, scagliola, stonewood, tileine, and velvetile.

Manufacture of Wood Pulp by the Sulphite Process. Considerable amounts of magnesite are consumed in the manufacture of chemically prepared wood pulp, for use in the manufacture of paper. The preparation of wood pulp by this process consists in boiling the wood with a chemical reagent which will serve as a disintegrating agent. For this purpose either sulphurous acid or calcium or magnesium bisulphite are generally used. The magnesium bisulphite is generally preferred, however, because of its greater stability and because of its greater solvent action on wood resins.

Manufacture of Carbon Dioxide. Considerable quantities of carbon dioxide were formerly manufactured from magnesite, but limestone or coke is now generally used for this purpose. Carbon dioxide is manufactured from crude magnesite by calcination and the recovery, purification, and compression of the carbon dioxide gas evolved, the residual caustic magnesia being sold as a by-product. In practice it has been found, however, that in order to obtain the most efficient results in the manufacture of carbon dioxide the crude magnesite has to be calcined at a lower temperature than that required to produce caustic calcined magnesite, that is, the residue contained too much carbon dioxide. On this account the use of magnesite for the manufacture of carbon dioxide is decreasing.

Since the calcination of the crude magnesite effects a reduction in weight of nearly 50 per cent it has been generally found to be more economical to calcine the magnesite at the mine and reduce the cost of shipment, and usually no attempt is made to save the carbon dioxide in this operation.

"Cold Water" Paint. Because of its refractory qualities caustic calcined magnesite is now used in the manufacture of fireproof paint. For this purpose a finely ground mixture of caustic calcined magnesite and magnesium chloride is prepared and is mixed with cold water for application.

Metallic Magnesium. Prior to the war the world's supply of metallic magnesium was largely produced in Germany where it was manufactured from magnesium salts obtained from the salt deposits at Stassfurt. It is now being produced in considerable quantities in France, England, United States, and Canada. Owing to the increased demand for the metal for military purposes and restricted importation the price of magnesium rose rapidly in United States after the outbreak of the war from $1.40 per pound to $5 to $10 per pound in 1914. During 1915 the prevailing price in New York was $5 per pound, but it has since fallen considerably, present quotations being $3.50. The importation of magnesium into United States before the war according to the statistics of the Department of Trade and Commerce was 38,000 pounds per annum. This, according to Dr. W. M. Grosvenor,[1] was considerably less than the actual consumption, the magnesium being imported by some manufacturers under other names. The normal consumption in United States for domestic purposes is stated by Dr. Grosvenor to be 50,000 pounds per year, an amount approximately equivalent to 90,000 tons of crude magnesite. The total production of metallic magnesium in United States in 1915 was 87,500 pounds valued at about $440,000.[2]

The usual process employed in Germany for the manufacture of magnesium was by the electrolysis of the fused double chloride $MgCl_2$ Kcl. It is said that it can also be made by the following processes: the reduction of magnesium chloride with metallic sodium; the reduction of the oxide with carbon; the electrolysis of magnesia; the reduction of fused chloride with aluminum; the reduction of the oxide or carbonate to slag forming residues; and other processes.[3]

In Canada, metallic magnesium is now being manufactured electrolytically from magnesite by the Shawinigan Electrometals Company at Shawinigan,[4] Quebec. The details of the process employed have not been published, but Canadian magnesite is being employed[5] as the crude material.

The principal use of metallic magnesium is as an alloy with aluminum (magnalium) copper, nickel, zinc, lead, iron, bismuth, and other metals.

[1] Metal. and Chem. Eng., vol. 14, 1916, p. 262.

[2] U.S. Geol. Surv., Mineral Resources, 1915, pt. 1, p. 737.

[3] Grosvenor, Dr. W. M., Metal. and Chem. Eng., vol. 14, 1916, pp. 262-264.

[4] Stansfield, Dr. A., "Electric furnaces as applied to non-ferrous minerals," Min. Jour. (Lond.) vol. 113, 1916, pp. 233-234.

[5] Letter from Dr. A. Stansfield.

Of these alloys, that with aluminum has been found to be exceptionally valuable. An addition of 2 per cent of magnesium to aluminum doubles its tensile strength, quadruples its resistance to jar or shock, and reduces its cost of machining over 50 per cent.[1] Magnesium is also used for scavenging alloys and for the illumination in flashlight photography and fireworks, and for military purposes in star shells, shrapnel trailers, etc.

Magnesium Sulphate. Large quantities of magnesium sulphate (Epsom-salt) are consumed in United States and Canada annually, the larger part of which prior to the war was imported from Germany, where it was produced as a by-product from the Stassfurt salt deposits. It can also be manufactured by treating magnesite or dolomite with sulphuric acid and is produced in this manner in United States. Magnesium sulphate is used chiefly for medicinal purposes, in tanning leather, in cotton manufacture, and in chemical laboratories.

Magnesium Chloride. The magnesium chloride consumed in America was formerly imported almost entirely from Germany, but is now being produced in United States by treating magnesite or serpentine with hydrochloric acid. It is also obtained as a by-product from the bitterns of salt refineries. Magnesium chloride is used in the manufacture of oxychloride cement, in the manufacture of cold water paint, in the manufacture of cotton goods, and in chemical laboratories.

Light Magnesium Carbonate (magnesia alba levis). The light or basic magnesium carbonate ($MgOH, 3MgCO_3$) can be prepared from magnesium sulphate or chloride, but is also manufactured from magnesite and dolomite. This product is used as a toilet preparation, for medicinal purposes, and as a heat insulator on boilers, pipes, etc.

Miscellaneous Uses. There are numerous other minor uses to which magnesite and its derivatives are applied. It is used as carbonate to prevent scale in boilers, where sulphurous waters are used; as carbonate in tooth paste; as oxide in dynamite; as oxide in the rubber industry, and as hydrate (milk of magnesia) for medicinal purposes.

FOREIGN SOURCES OF SUPPLY.

Although deposits of magnesite are known to occur in numerous localities throughout the world, the principal part of the world's production, prior to the war, was derived from only two countries, Austria-Hungary and Greece. The deposits in United States are also of interest in this connexion, however, since a large part of the magnesite mined in Canada is exported to that country.

Austria-Hungary. Magnesite is known to occur in numerous widely scattered localities in Austria-Hungary, but the deposits on which mining operations are being carried on are limited to the central part of

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[1] Grosvenor, Dr. W. M., Metal and Chem. Eng., vol. 14, 1916, p. 263.

the province of Styria (Steigermark) in Austria and to northwestern Hungary. In the first locality the most important deposits occur near the town of Veitsch. The largest deposits in northwestern Hungary lie between the towns of Jolsva and Nyusta.

The magnesite found in Austria-Hungary is mainly a grey to drab variety, occurring in association with talc, quartz, dolomite, calcite, pyrite, and other minerals as enormous lenticular masses several hundred feet in diameter. The larger part of the impurities contained in the magnesite are removed in practice by cobbing at the mine and by sorting after the product has been calcined; so that except for the iron which it contains a magnesite of a fair degree of purity is produced. It is said that the Austro-Hungarian magnesite, owing to the iron which it contains, is more readily reduced to the dead burned state and that the iron oxide contained in the product serves as a binder in making furnace linings and in the manufacture of magnesite brick, and that on this account, except where a more highly refractory material is required, Austro-Hungarian magnesite is preferred.[1] Analyses follow:

Chemical Analyses of Typical Austro-Hungarian Magnesite.

	I	II	III	IV	V
SiO_2	0·45	0·76	5·83	0·74	0·74– 0·76
Al_2O_3	trace	0·14	0·48	0·39	0·39– 0·27
Fe_2O_3	3·65	5·72	1·54	3·27	3·27– 3·43
Mn_2O_3	trace	0·94	....	....	
CaO	0·97	0·32	4·52	0·20	1·20– 0·90
MgO	43·82	43·06	39·54	44·80	44·80–45·00
CO_2	50·44	49·81	47·99	50·10	50·10–50·20
Total	99·33	100·25	99·90	99·50	

I. Veitsch, Fortschritte der Min., Krist. und Pet., vol. 4, 1914, p. 29.
II. Britenau, " " " " "
III. Dienten, Eicheiter C. F., Jahrb. d.k.k. geol. R.A., 1907, p. 927.
IV. Jolsva, Fortschritte der Min., Krist., und Pet., vol. 4, 1914, p. 32.
V. Nyustya, Bull. 355, U.S.G.S., 1908, p. 56.

Because the Austro-Hungarian magnesite deposits are closely associated with Palæozoic marine sediments it was formerly assumed that the magnesite was of sedimentary origin; but the closer study of the deposits during recent years has lead to the conclusion that they are in reality metamorphic deposits formed by the action on Palæozoic limestone[2] of magnesium carbonate solutions, derived from basic intrusives.

[1] Morganroth, L. C., "The occurrence, preparation, and use of magnesite," Bull. Am. Inst. Min. Eng., 1914, No. 93, pp. 2345-2352.

[2] Rumpf, J., "Ueber kristallisierte magnesite aus den nordöstlichen Alpen, Tschermak's Mineralogische Mitt., 1873, p. 263.

Weinschenk E., Grunzuge der Gesteinskunde, Freiberg vol. 2, 1905, p. 315.

Redlich, Karl A., Fortschritte der Min. Krist. und Pet. vol. 4, 1914, pp. 9-42.

Kern, A., Der Magnesit und Seine technische Verwertung, Glückauf, 1912, pp. 271-275.

The quantity of calcined magnesite exported from Austria-Hungary during the years 1909 to 1913 was as follows:

	Metric tons.
1909	125,666
1910	182,911
1911	147,481
1912	171,196
1913	200,947

Greece. Magnesite is found at a number of localities in Greece, but the important deposits are situated on the island of Euboea, where it occurs associated with serpentine in numerous masses and veins up to 50 feet or more in width and several hundred feet in length. The magnesite is of the massive variety and contains the usual associated quartz, dolomite, and other impurities. The larger part of these are cobbed out in mining the material, however, so that a product of exceptional purity is produced. Analyses follow:

Analyses of Typical Grecian Magnesite.

SiO_2	0·20	0·90	0·38	1·63
Al_2O_3	0·20 }	0·86	{0·15	0·17
Fe_2O_3	0·20 }		{0·08	1·19
CaO	0·51	1·53	1·68	1·44
MgO	47·11	45·45	46·09	45·75
CO_2	51·77	51·26	51·51	49·88
Total	98·99	100·00	99·89	100·06

Since the Euboean magnesite deposits are all situated in close proximity to the seashore, under normal conditions Grecian magnesite has the advantage of cheap water transportation to the principal magnesite markets of the world. Production was as follows:[2]

Production of Magnesite in Greece for the Years 1911 to 1913.

	1911	1912	1913
	long tons	long tons	net tons
Crude	27·892	36·519	9 517
Calcined	22·987	30·645	31·815
Dead burned	6·422	5·408	......

United States. Magnesite is known to occur in numerous localities in United States, but the only deposits of sufficient extent to be of com-

[1] Hogg, James, Trans. Inst. Min. Eng., vol. 46, 1913-1914, pp. 128-148.
[2] Rousch, G. A., Mineral Industry, 1914.

mercial importance, so far discovered, occur in the state of California.[1] There they are found in numerous widely scattered localities throughout the coast range and on the western slope of the Sierra Nevadas, extending from Mendicino county in the north to Riverside county in the south, a distance of approximately 500 miles. Deposits of considerable size are said to occur in eleven different counties in this territory, but up to the outbreak of the war mining operations on most of the properties had scarcely passed the prospect stage. The most important deposits are situated in Tulare, Sonoma, and Santa Clara counties, a considerable part of the total production of the state being derived from deposits in the vicinity of Porterville, Tulare county.

With the exception of certain deposits of magnesite near Bissel in Kern county, which occur associated with clays and clay shales and on that account are regarded as of sedimentary origin, all the Californian magnesite deposits occur as irregular veins, masses, or stockworks in serpentine resulting from the alteration of magnesian igneous rocks. Though in some localities veins and masses of magnesite 20 feet or more in width are present, most of the deposits consist of numerous small veins; and, in consequence, a considerable portion of the material mined requires hand sorting and the proportion of waste rock is large.

The chemical composition of typical samples of Californian magnesite is indicated in the following table:

Chemical Analyses of Californian Magnesite.

	I	II	III	IV
Silica	2·28	7·67	0·73	4·73
Alumina	0·03	0·26	0·14	0·12
Ferric oxide	0·26	0·29	0·21	0·08
Lime	1·32	0·04	0·40	0·43
Magnesia	45·17	43·42	46·61	44·73
Carbon dioxide	50·74	48·08	51·52	49·40
Total	99·80	99·76	99·61	99·53

I. Porterville, Tulare county, Bull. 355, U.S.G.S., 1908, p. 56.
II. Red Slide, Sonoma county, Bull. 355, U.S.G.S., 1908, p. 26.
III. Red Mountain, Santa Clara county, Bull. 355, U.S.G.S., 1908, p. 36.
IV. Near Winchester, Riverside county.

The preceding analyses indicate that in chemical composition the Californian magnesite differs little from the Grecian magnesite; but the higher cost of production and transportation has made it difficult for the Californian magnesite to compete with the Grecian product even on

[1] Deposits of magnesite of possible commercial importance have recently been reported to occur near St. Thomas in Clark county, Nevada, and in the northern part of the state of Washington. Eng. and Min. World, vol. XLIV, 1916, p. 482, and Eng. and Min. Jour., vol. CIII, 1917, p. 601.

the Pacific coast of United States, considerable Grecian magnesite being sold there annually in competition with the local output. The price of Californian magnesite in San Francisco during the years preceding the war ranged from $8 to $12 per ton for crude, and from $25 to $30 per ton for unground calcined, and from $35 to $40 for ground calcined; during the same period Grecian magnesite sold f.o.b. New York at $7 to $8 per ton for crude, $17.50 to $20 per ton for unground, and at $25 to $30 for ground. Since the principal industries in which magnesite is used are situated in the eastern part of United States, and the freight rate between the Pacific and Atlantic coasts is $10 per ton by rail, and $7 per ton by water, it is impossible for the Californian magnesite to compete with the foreign product in the eastern market under normal conditions.

The production of magnesite in United States for the years 1911 to 1915 inclusive, as given in the report of the United States Geological Survey, was as follows:

	Short tons.	Value.
1911	9,375	$16,326
1912	10,512	84,096
1913	9,632	77,056
1914	11,293	124,223
1915	30,499	274,491

The importation of magnesite and magnesia for the years 1911 to 1915 as given under these headings in the report of the United States Department of Commerce was as follows:

United States Imports of Magnesia and Magnesite.

	1911		1912		1913		1914		1915	
	tons	value	tons	value	tons	value	tons	value	tons	value
Magnesia		$		$		$		$		$
Calcined (medicinal)....	46	13,694	52	16,326	27	10,034	80	19,342	47	10,451
Carbonate (medicinal)..	25	2,867	30	2,727	35	4,880	23	2,527	24	2,757
Sulphate (Epsom-salt) .	2,975	22,559	5,352	41,739	4,062	32,884	6,913	53,768	1,780	16,050
Magnesite										
Calcined not purified...	122,075	1,109 770	125,252	1,265,339	167,099	1,672,565	121,817	1,323,194	26,574	232,071
Crude................	12,974	76,097	17,905	104,326	13,240	84,911	13,354	54,677	49,768	255,140

OTHER CANADIAN MAGNESITE DEPOSITS.

The occurrence of magnesite in numerous widely scattered localities in Canada is recorded in the reports of the Canadian Geological Survey, but the meagre information given with regard to most of the occurrences indicates that most of the deposits are of too limited extent or are too remote to be of commercial importance. In New Brunswick a vein of magnesite several feet wide is said to occur in grey chloritic schist on the bay shore of St. John county near West Beach.[1] In Quebec, magnesite is found (in addition to the Grenville district) associated with serpentine and talc in Sutton and Bolton townships, Brome county. One of these deposits on lot 17, range IX, Bolton township,[2] is stated to be 20 yards wide. In Ontario, a blue ferruginous magnesite occurs in association with finely crystalline pyrite on Lac des Mille Lacs,[3] Algoma district. In British Columbia, the presence of magnesite is recorded at Illecillewaet in the Kootenay district,[4] on Germansen creek in the Omineca district[5], at 108-Mile House on the Caribou road in the Lillooet district,[6] and in the vicinity of the town of Atlin in the Atlin Mining Division.[7] In Yukon Territory ferruginous magnesite was observed by Mr. R. G. McConnell on Big Salmon river, a tributary of the Lewes river, and on Yukon river about 1½ miles above the outlet of Indian river. In the first mentioned locality the magnesite occurred in a band 50 feet thick in association with dark, partly altered slates, greenish schists, and serpentine.[8] Magnesite is also reported to occur in sedimentary beds on the Yukon-Alaska boundary north of Porcupine river.[9]

In the Atlin Mining Division of British Columbia both magnesite and hydromagnesite were observed by Gwillim, but the extensive masses of hydromagnesite occurring in the vicinity of the town of Atlin are the most important. These deposits are superficial beds of fine powdery white hydromagnesite having a thickness ranging from 8 feet to 6 feet and covering areas up to 18 acres in extent.[10]

Analyses of this material made by Mr. N. L. Turner of the Mines Branch gave the following results:

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[1] Bailey, L. W., and Matthews, G. F., "Preliminary report on the geology of southwestern New Brunswick," Geol. Surv., Can., Rept. of Prog., 1870-1871, p. 237.

[2] Geology of Canada, 1863, p. 457.
Geol. Surv., Can., Ann. Rept. new ser., vol. IX, 1896, p. 95 S.

[3] Geol. Surv., Can., Ann. Rept., new ser., vol. 1, 1889, pt. M., p. 22.

[4] Geol. Surv., Can., Ann. Rept., new ser., vol. IX, 1896, p. 96S.

[5] McConnell, R. G., "Report on an exploration of the Findley and Omineca rivers," Geol. Surv., Can., Ann. Rept., vol. VII, 1894, p. 25.

[6] Geol. Surv., Can., Ann. Rept., vol. 11, 1898, p. 10.

[7] Gwillim, J. C., Geol. Surv., Can., Ann. Rept., vol. XII, 1899, p. 72A and p. 46B.

[8] Geol. Surv., Can., Ann. Rept., vol. 11, 1898, pp. 16-17R.

[9] Cairnes, D. D., Geol. Surv., Can., Sum. Rept., 1911, p. 33.

[10] Young, G. A., Geol. Surv., Can., Sum. Rept., 1915, pp. 50-61.

Analyses of Hydromagnesite from Atlin, B.C.

SiO_2	1·86	0·90	0·54	0·74	0·96
Al_2O_3	0·67	0·10	0·17	0·35	0·23
Fe_2O_3	0·15	0·09	0·11	0·15	0·12
FeO	0·60	0·45	0·64	0·66	0·53
CaO	2·04	0·82	0·68	0·32	0·16
MgO	41·13	42·35	42·19	42·85	43·04
CO_2	35·98	36·10	36·17	36·35	36·21
H_2O +	18·02	18·95	19·05	19·10	19·26
Total	100·45	99·76	99·55	100·52	100·51
H_2O −	1·92	1·61	1·35	1·21	9·34

A number of hypotheses to account for the origin of the hydromagnesite have been proposed by those who have studied the deposits in the field. Gwillim suggested that the material has been deposited from springs, an hypothesis which seemed to be supported by the results of analyses of water from the springs of the district, since these were found to include considerable magnesia. Robertson[1], who examined the deposits in 1904, concluded, however, that the hydromagnesite was a product resulting from the weathering of magnesia-rich rocks directly underlying the deposits. Young[2], on the other hand, pointed out that the deposits have not the tuffaceous structure of spring deposits and do not rest on magnesia-rich rocks but on soil, and concluded, therefore, that there are valid objections to the hypotheses of Gwillim and Robertson, and suggested that the hydromagnesite represents material deposited on the bottoms of ponds which have disappeared since the deposition occurred.

It is estimated by Young that two groups of deposits occurring in the outskirts of the town of Atlin contain approximately 180,000 tons of hydromagnesite.

Recently C. W. Drysdale[3] has discovered magnesite near the northwest end of Liza lake in Bridge River district, Lillooet mining division, British Columbia. The magnesite found in this locality is a buff yellow massive variety occurring as masses and veins in serpentinized magnesian rocks and is thus similar in character and origin to the deposits of California.

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[1] Robertson, W. F., Rept. of Minister of Mines, B.C., 1915, pp. 82-83.
[2] Geol. Surv., Can., Sum. Rept., 1915, pp. 55-61.
[3] Geol. Surv., Can., Sum. Rept., 1915, p. 83, and 1916, p. 48.

Analyses of the magnesite made by Mr. N. L. Turner of the Mines Branch resulted as follows:

Analyses of Magnesite from Bridge River, B.C.

SiO_2	7·46	4·08
Al_2O_3	0·23	0·59
FeO	0·56	
Fe_2O_3	0·25	0·95
CaO	0·46	3·25
MgO	43·42	42·20
CO_2	47·28	
H_2O+	0·58	
H_2O-	0·10	
Total	100·34	99·62

The outcrop from which the above representative samples were taken measured 52 feet by 48 feet, indicating that the deposits are extensive. They are situated at a distance of over 30 miles from the nearest point on the Pacific and Great North-Eastern railway, however, and are, therefore, too remote to be profitably mined at present.

A deposit of magnesite has recently been discovered near Orangedale, Inverness county, Cape Breton island. The magnesite is a brown crystalline variety having the following composition:

SiO	Al_2O_3	Fe_2O_3	$MgCO_3$	$CaCO_3$
0·30	1·01	1·71	90·80	2·85

Total, 96·67

When visited by A. O. Hayes of the Geological Survey in the summer of 1916 an outcrop about 100 square feet in area was exposed, protruding through sand and clay. Since that time 30 tons of magnesite have been mined from the deposit by the Nova Scotia Steel and Coal Company which has acquired possession of the property.

PRODUCTION.

The production of magnesite in Canada since the year 1908 as compiled by the statistical division of the Department of Mines is as follows:

Year.	Tons.	Value. $
1908	120	840
1909	330	2,508
1910	323	2,160
1911	991	5,531
1912	1,714	9,645
1913	515	3,335
1914	358	2,240
1915	14,779	126,584
1916	55,413	563,829

HISTORY OF MAGNESITE MINING IN GRENVILLE DISTRICT.

In the month of June 1900, Reverend W. P. Boshart in the course of a visit to Mr. Donald McPhee, lot 15, range IX, Grenville township, observed a boulder lying a short distance from Mr. McPhee's house which had a whiter and more glistening appearance than the ordinary crystalline limestone of the district. He sent a specimen of the material to Mr. W. B. McAllister of Ottawa, who took the sample to the Geological Survey where it was determined to be magnesite. Learning that magnesite was of commercial value, a search for the mineral in place was undertaken by Messrs. McAllister and Boshart with the result that outcrops and boulders of similar material were found in numerous localities in the district. Later in the season Mr. R. L. Broadbent of the Geological Survey visited these localities and collected samples which were analysed by Mr. F. G. Wait of the section of chemistry and mineralogy of the Geological Survey. The results of these analyses were published in the report of the Geological Survey for 1900.[1]

Following the discovery of the magnesite, Messrs. McAllister and Boshart procured options on a large part of the territory in which the magnesite was known to occur, and made trial shipments of the material to consumers of magnesite, but the prices offered were too low for profitable operation, and no further attempts were made to market the material until the year 1907, when Mr. T. J. Watters purchased the mining rights for the north half of lot 18, range XI, Grenville township, from the Government and organized the Canadian Magnesite Company to operate the property. Later this company also acquired the mining rights for lot 15, range IX, Grenville, from Mr. McPhee, and erected a 10-ton keystone kiln on this lot for the purpose of calcining the magnesite at the mine, thus reducing the cost of haulage to the railway at Calumet, 11 miles distant. Mining operations were continued by the Canadian Magnesite Company on lot 15, range IX, in a small way, until the year 1914, when the property of the Canadian Magnesite Company was taken over by the North American Magnesite Company. Since that time mining has been actively prosecuted, both crude and calcined magnesite being shipped.

In 1915 Mr. S. Melkman of Montreal organized the Scottish Canadian Magnesite Company to mine magnesite on lots 15, ranges X and XI, Grenville township, under contract with the Grenville Lumber Company, to which these properties belonged. Magnesite mining was commenced in the month of August, 1915, by this company and has been continued up to the present. Since that time the Scottish Canadian Magnesite Company has acquired the controlling interest in the Grenville Lumber

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[1] Geol. Sur., Can., Ann. Rept., vol. XIII, 1900, pt. R., pp. 14-19

Company and has constructed a light railway 14 miles in length connecting their deposits with the Canadian Pacific railway at a point about 2 miles east of Grenville station.

In October 1916, Mr. A. Lannigan and Mr. J. Milway of Calumet discovered a deposit of magnesite on lot 13, range I, Harrington township, which has since been acquired and operated by the International Magnesite Company of Montreal.

Some development work on magnesite prospects has also been performed by Messrs. Boshart and Fitzsimmons during the past year and a few tons of magnesite shipped. The larger part of these shipments were derived from boulders, however, and not from the magnesite in place.

CHAPTER II.

GENERAL GEOLOGY.

GENERAL STATEMENT

The rocks occurring in the Grenville district when classified in a general way according to their age and structure fall into four definite groups:

(1) A basal group of Pre-Cambrian rocks which have all been more or less deformed and metamorphosed.
(2) Intrusive igneous rocks of late Pre-Cambrian age.
(3) Approximately flat-lying sandstone shale and sandstone of early Palæozoic age.
(4) Unconsolidated gravel, sand, and clay of Pleistocene and Recent age.

Arranged in tabular form the succession of formations in the district in detail is as follows:

Table of Formations.

Quaternary..........	Champlain..................	Marine clay and sand.
	Glacial.....................	Boulder clay, gravel, and sand
Palæozoic............	Chazy......................	Sandstone, shale, and limestone.
	Beekmantown..............	Limestone.
	Potsdam...................	Sandstone.
Late Pre-Cambrian ..	....	Granite, quartz syenite, syenite.
		Diabase.
Early Pre-Cambrian..	....	Granite-syenite gneiss.
		Metamorphic pyroxenite.
	Buckingham (igneous) series...	Pyroxene syenite. Pyroxene diorite. Pyroxene gabbro. Pyroxenite.
	Grenville series..............	Quartzite, garnet-sillimanite gneiss, crystalline limestone.

BASAL COMPLEX.

General Statement.

The basal complex, the oldest of the four great groups into which the rocks of the Grenville district have been subdivided, is composed of a heterogeneous assemblage of sedimentary and igneous rock types which, though not all contemporaneous in age, have all been partly or completely transformed to a crystalline or foliated condition as a result of the regional metamorphism to which they have been subjected. In this respect they are strikingly in contrast with the rocks that succeed them in that the latter are not metamorphosed and retain all the characteristics by which they were originally distinguished. If classified merely on the basis of age, the rocks of the complex must be regarded as belonging to only three groups: (1) a group of recrystallized marine sediments constituting the Grenville series; (2) a group of igneous pyroxenic rocks of intermediate composition intruding the rocks of group 1, constituting the Buckingham series; and (3) batholithic masses of granite and syenite gneisses intrusive into the rocks of groups 1 and 2. But the metamorphic action of the pyroxene gneisses of group 2 on the limestone member of the Grenville series has transformed considerable masses of this rock into diopside and related minerals forming a fourth common rock type generally known as "pyroxenite."

The rocks of the Grenville series, being the least resistant to erosive agencies of all the rocks in the district are generally found to underlie the valleys, whereas the granite gneisses which are least easily eroded, form all the prominent hills (Plate I).

Grenville Series.

The oldest rocks recognized to be present in the Grenville district belong to what is 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 intense metamorphism to which they have been subjected, the shale has been recrystallized to sillimanite-garnet gneiss (Plate II), the sandstone to vitreous quartz, and the limestone to crystalline limestone (Plates III and IV). The reasons for this conclusion are: (1) chemical analyses of the sillimanite-garnet gneiss member of the series show that this rock has in every detail the chemical composition of a shale and thus the three rock types, sillimanite-garnet gneiss, quartzite, and crystalline limestone have respectively the composition of the three dominant members of marine sedimentary series of the well sorted types, and (2) these rocks occur interstratified with one another in a manner similar in every respect to the way normal marine sedimentary deposits usually occur.

Buckingham Series.

The Buckingham series is a group of igneous pyroxenic rocks found widely distributed throughout the Pre-Cambrian of southern Quebec and eastern Ontario. In the district where the series was originally described members of the series occur ranging in composition from pyroxene granite to peridotite; but in the Grenville district only pyroxene syenite, pyroxene diorite, pyroxene gabbro, and pyroxenite were observed. These have been intruded in the Grenville series partly as thin bands injected between the beds or along the planes of foliation and partly as large lenticular bosses. Since their intrusion they have been subjected to intense deformation and are generally more or less foliated, the gneissoid structure being especially well developed in the thin *lit par lit* injections.

Metamorphic Pyroxenite.

The rocks of this class generally occur as irregular discontinuous masses or bands, elongated in the direction of the strike of the garnet gneiss, quartzite, limestone, pyroxenic gneisses, and other rocks with which they are associated. The pyroxenite in its most typical occurrences is mainly composed of a pale green to white massive or granular pyroxene having approximately the composition of diopside, throughout which red or blue microcline commonly occurs as scattered crystals or in pegmatitic masses. With the pyroxene are associated a great variety of other minerals of which the following are the most common: scapolite, calcite, phlogopite, apatite, tourmaline, green amphibole, pyrite, chalcopyrite, titanite, fluorite, quartz, and prehnite. These minerals may occur as individual crystals scattered through the pyroxenite, as encrustations on the walls of geodal cavities, as inclusions in calcite, or as irregular veins. From the study of the character and relationships of the pyroxenite in the Grenville and other districts it has been concluded that this rock is a secondary type, formed from the crystalline limestone of the Grenville series by the action of pegmatitic solutions derived from the intrusives of the Buckingham series.

Granite-Syenite Gneiss.

The granite and syenite gneisses composing the third member of the basal complex are the most widespread of all the rocks found in the district, occurring as enormous batholiths and small masses and bands which have intruded their way through the rocks of the Grenville and Buckingham series. Lithologically, the granite and syenite gneisses are pink to grey rocks consisting of granular feldspar or granular feldspar and quartz with biotite or hornblende or biotite and hornblende together as the ferromagnesian constituent. In places the rocks of this group are fine-grained and aplitic in appearance, and in other localities they are exceedingly coarse and porphyritic throughout wide areas.

The relationships of the masses of granite gneiss and syenite gneiss to the older rocks into which they were intruded seem to indicate that these masses made room for themselves in two principal ways: (1) by thrusting aside the older rocks; and (2) by *lit par lit* injection. That the batholiths made room for themselves in part, in the first manner, is indicated (1) by the distribution of the older rocks in the form of belts and scalloped-shaped areas intervening between the batholiths and (2) by the manner in which the foliation, banding, and bedding in the intruded rocks tend to parallel the batholithic margin. This parallelism is especially well developed in the easily deformed limestone member of the Grenville series. The second mode of intrusion was evidently a widespread phenomenon, for throughout the larger part of the batholithic masses of granite and syenite there are numerous included bands of garnet gneiss, quartzite, and pyroxenic gneiss ranging in width from a fraction of an inch to several hundred feet, which are penetrated by numerous transverse dykes emanating from the adjoining granite and syenite (Plate V).

LATE PRE-CAMBRIAN INTRUSIVES.

General Statement.

The rocks occurring in the Grenville district, which have been classed as late Pre-Cambrian, are igneous intrusions which are lithologically different from the rocks of the basal complex and unlike the rocks of the basal complex have not been greatly deformed or otherwise metamorphosed. On the other hand, no rocks of similar character have been observed to intrude the Palæozoic sediments which overlie the Pre-Cambrian in the southern part of the district. It is probable, therefore, that these intrusives are not only considerably younger in age than the basal complex but also are older than the Palæozoic and are, therefore, late Pre-Cambrian in age. They include two separate types of intrusives: (1) diabase dykes and (2) a single stock-like mass of granite, quartz syenite, syenite, and quartz syenite porphyry.

Diabase.

The rocks of this class occur as numerous approximately east-west trending dykes of diabase ranging from less than a foot to several hundred feet in width, which form part of a widely extended dyke system which parallels the southern margin of the Laurentian plateau for a distance of at least 150 miles in this region. The diabase is a typical, fine-grained to coarse variety consisting of labradorite, augite, and scattered grains of ilmenite.

Granite, Quartz Syenite, Syenite, Quartz Syenite Porphyry.

Extending along the margin of the Laurentian plateau to the northeast of the town of Grenville there is an elliptical-shaped mass of rock approximately 8 miles in length and 5 miles in width, which has been intruded abruptly across the rocks of the basal complex, and which for the purpose of description might be designated the Grenville stock. In composition, the mass consists mainly of grey to pink, medium-grained feldspar and dark green hornblende with varying porportions of quartz so that all intermediate types between a granite and a syenite are present, although on the whole the granite is most abundant. Within the granite and syenite there are also numerous masses of fine-grained, dark grey, to pink aphanitic quartz syenite porphyry. The relationships of these masses in places is somewhat obscure, but at other points they are cut across by numerous dykes of the granite syenite indicating that in part, at least, they are included blocks and older in age than the granite syenite.

Though the Grenville stock is not found in actual contact with either the diabase dykes or the Palæozoic sediments occurring in the district, it is probable, as was concluded by Sir William Logan, who studied the mass in 1853, that it is younger than the former and older than the latter; for the diabase dykes, although abundant throughout other portions of the region, have nowhere been observed to penetrate the stock, whereas dykes similar in composition to the granite syenite of the stock have not been observed to intrude the Palæozoic sediments which outcrop in close proximity to the stock on the south. It would seem probable, therefore, that the Grenville stock is very late Pre-Cambrian in age.

PALÆOZOIC.

That portion of the Grenville district which lies adjacent to Ottawa river and south of the Laurentian escarpment is underlain by approximately flat-lying beds of Palæozoic shale, sandstone, and limestone, which protrude here and there as ledges in the stream bottoms or as low east-west trending escarpments. The formations represented by these sediments named in ascending order include the Potsdam, the Beekmantown, and the Chazy.

PLEISTOCENE.

Glacial.

In common with the whole territory formerly covered by the Labradorean continental glaciers, the bedrock surface of this region is covered by an irregular mantle of glacial debris. This consists in the main of scattered boulders and irregular knobs or ridges of gravel and sand, in many parts of which deep undrained depressions occur.

Marine Clay and Sand.

Throughout all the lower portions of the Grenville district the glacial and older formations are overlain by stratified clay and sand which contain marine shells and which form extensive flats (Plate I) in the depressions within the Laurentian plateau. These marine deposits are found up to elevations of 735 feet above sea-level.[1] The character of these deposits varies considerably from point to point, but in the main, the clay beds predominate at the bottom and the sand at the top. In the vicinity of Ottawa river, the sand occurs in extensive areas, in places with a typical desert-like duned surface.

[1] According to elevations on Hawkesbury sheet published by the Department of Militia and Defence.

CHAPTER III.

MAGNESITE DEPOSITS.

DISTRIBUTION AND GEOLOGICAL RELATIONSHIPS.

The deposits of magnesite so far discovered in the Grenville district are found in four principal localities; the north end of lot 15, range IX, the south end of lot 15, range XI, and the north end of lot 18, range XI, Grenville township; and lot 13, range I, Harrington township.

At all of these points, the magnesite occurs associated with serpentine, dolomite, and other minerals in lenticular outcrops protruding through the marine clay and sand which, in this district, as everywhere in the Laurentian highlands adjoining the lower Ottawa and lower St. Lawrence, occupies the bottoms of the major valleys. On lot 15, range IX, Grenville township, the magnesite deposit is adjoined on the west by Grenville quartzite, and on the east at a distance of about 400 feet, outcrops of pyroxenic syenite belonging to the Buckingham series occur. On lot 15, range XI, Grenville township, the conditions are very similar to those on lot 15, range IX, Grenville quartzite occurring on the west and pyroxenic gneiss on the east, but between the pyroxenic gneiss and the magnesite several outcrops of metamorphic pyroxenite are present. On the Shaw property, lot 18, range XI, Grenville township, garnet gneiss belonging to the Grenville series occurs to the east of the deposit, metamorphic pyroxenite to the south, and crystalline limestone to the northwest. On lot 13, range I, Harrington township, the adjoining outcrops consist of pyroxenic gneiss, crystalline limestone, and garnet gneiss. In general, therefore, it may be said that the magnesite in all of its occurrences is found in association with the metamorphosed group of sediments, viz., crystalline limestone, garnet gneiss, and quartzite, composing the Grenville series, and that in three localities it is found in close proximity to outcrops of the pyroxenic rocks of the Buckingham series.

GENERAL CHARACTER.

The magnesite found in the Grenville district is a glistening cream white to milk white or grey material occurring in extensive masses associated with bands or lenses of dark green to light yellow serpentine. Serpentine also occurs disseminated in the magnesite in places and the magnesite nearly everywhere contains more or less included dolomite. Moreover, since dolomite ($CaCO_3$ $MgCO_3$) contains 30 per cent of lime, the magnesite generally contains a certain amount of lime also, the percentage present varying in proportion to the amount of dolomite which the magnesite contains. In a few localities the dolomite included in the magnesite is more coarsely crystallized, and is whiter in colour than the surrounding material, and can be distinguished in this way, but, throughout the great mass of the deposits, magnesite and dolomite are so similar in appearance that the presence of dolomite is difficult to detect.

The intimate manner in which dolomite is disseminated through the magnesite is made evident in several ways. Where the magnesite outcrop has been exposed to atmospheric agencies, dolomite, being more soluble than the magnesite, dissolves away more readily, so that the weathered surface presents an irregularly pitted appearance, the magnesite forming the prominences and the dolomite occupying the bottoms of the depressions. This feature is well exhibited in Plate VI. The presence of dolomite in the magnesite can also be detected by treating the mixture with cold concentrated hydrochloric acid, effervescence occurring where the dolomite is present. The relationship of the dolomite to the magnesite can best be observed in the material after it has been calcined in a kiln or furnace without access of air (deoxidizing atmosphere), the dolomite assuming a white and the magnesite a pink colour as a result of this operation. A number of specimens of magnesite collected by the writer were sawn and calcined in the ceramic laboratory of the Mines Branch of the Department of Mines by Mr. H. Frechette (Plates VII and VIII). It will be observed that in these specimens the dolomitic portions appear to be included in the magnesite and possess a most irregular outline.

STRUCTURE.

In highly crystalline metamorphosed rocks, such as comprise the Grenville magnesite deposits, structural features are not everywhere apparent; but, in some of the deposits, parallel planes of parting, banding, and other features are conspicuous. The outcrops in which the magnesite is found are all elongated in a direction approximately parallel to the trend of the bedding of the quartzite and garnet gneiss belonging to the Grenville series which outcrop in the vicinity of the deposits; likewise, within the deposit the elongation of the masses of serpentine, the strike of the planes of parting, and the banding, which characterize the magnesite, all trend in a direction parallel to the longer direction of the outcrop and the strike of the adjoining Grenville sediments.

The banded structure generally present in the magnesite arises in part from variations in the colour of the magnesite and in part from variations in the proportion of disseminated serpentine which it contains. The width of the successive bands is exceedingly variable ranging from less than an inch to one foot, although on the whole the wider bands are most common. It was observed that the proportion of serpentine in the bands changed in places when followed along the strike of the bands and, that at some points, the banded magnesite passed by a gradual increase in the proportion of disseminated serpentine into solid masses of serpentine.

The most conspicuous structural feature exhibited by the magnesite deposits is their prevailing lenticular form. Along the eastern margin of the main pit on the McPhee property (lot 15, range IX, Grenville township) there is a northeasterly trending lens (sample area 97, Map 1679) of medium to coarse-grained, white dolomite, 60 feet long and 10 feet wide; 50 feet to the south of this lens there is a parallel trending lens (sample area 114, Map 1679) of coarse grey dolomite, 100 feet long and 20 feet wide, in which pyrite and zinc blende are disseminated. Both of these lenses apparently lie on the eastern flank of a still larger lens; for, their axial planes, as well as the banding in the adjoining magnesite, dip 75 degrees towards the southeast, whereas 50 feet westward the dip of the banding and planes of parting in the magnesite are 75 degrees towards the northwest. A still more striking example of the lenticular form is that exposed in the west face of the northern pit on the same property. At the south end of this face the banding and parallel planes of parting in the magnesite have approximately an east-northeast strike and a dip gradually curving downward towards the north-northwest. At the north end of the face 80 feet farther to the north the strike is approximately east and the dip curves downward toward the south at the top of the face but reverses back to the northward at the bottom. On the face of this pit, therefore, there is apparently exhibited a cross section of the lower portion of a large distorted lens.

DEFORMATION.

That the magnesite deposits have been intensely faulted, crumpled, and otherwise deformed is indicated by numerous slickensided surfaces, dislocations in the banding along planes of fracture, and variations in the strike and dip of the banding and planes of parting. One of the most striking evidences of deformation in the deposits was observed near the west side of the pit on No. 3 outcrop, lot 15, range XI, Grenville township. At this point there is a dyke of biotite-pyroxene syenite, 6 inches in width, which has been crumpled into a closely compressed anticline. The magnesite exposed in the southern pit on No. 2 outcrop on the same property was also observed to be granulated in places—another evidence of intense deformation. It is probable that the lenticular structure so common in the magnesite deposits is also the result of deformation, since the banding in the magnesite adjoining the lenses everywhere conforms to the margin of the lens. This feature is exceptionally well shown where the magnesite adjoins a crumpled lens of serpentine in sample areas Nos. 41 and 42, on the No. 1 outcrop on the Scottish Canadian property (Map 1679).

MINERALOGY.

The minerals observed to be present in the magnesite deposits, named in the order of their abundance, are as follows: magnesite, serpentine, dolomite, diopside, phlogopite, quartz, talc, pyrite, sphalerite, magnetite, and graphite. The character and mode of occurrence of each of these are briefly described in the following sections.

Magnesite (*$MgCO_3$: magnesium 47·6, carbon dioxide 52·4 per cent*). Magnesite or magnesium carbonate as found in the Grenville district is a glistening cream white, snow white, milk white, or grey, fine-grained material having a specific gravity of 3·00 and a hardness of 3·5. The general character and mode of occurrence of the mineral have been described in previous sections.

Serpentine (*$3MgO. 2SiO_2. 2H_2O$: magnesia 43, silica 44·1, water 12·9 per cent*). The serpentine found in the magnesite deposits occurs partly in masses or bands of various sizes up to several hundred feet in length and 50 feet in width and partly as round grains disseminated through the magnesite or magnesite-dolomite. It may be dark green or almost black, emerald green, blue green, yellow green, yellowish brown or wax yellow in colour, is exceedingly fine-grained, and possesses a waxy lustre. In the larger masses it commonly contains considerable finely disseminated amber brown mica.

Dolomite (*$CaCO_3MgCO_3$: magnesia 21·7, lime 30·4, carbon dioxide 47·9 per cent*). The dolomite associated with the Grenville magnesite occurs partly as small grains or aggregates of grains intimately disseminated through the magnesite, and partly as large irregular masses or lenses included in the magnesite. Corresponding to these two modes of occurrence there is a marked difference in the physical character of the mineral: for, while the disseminated dolomite is generally fine-grained and glistening and similar in appearance to the magnesite, the large masses are coarsely crystallized with a well developed rhombohedral cleavage.

Diopside (*$CaMg(SiO_3)_2$: lime 25·9, magnesia 18·5, silica 55·6 per cent*). Extensive masses of the variety of pyroxene known as diopside are included in the magnesite deposits in a number of localities, especially near the contact of the magnesite with the Grenville quartzite which adjoins the deposits in places. The mineral as found in these masses is not strikingly different in appearance from the magnesite. It can be distinguished, however, by its somewhat greater specific gravity, rectangular cleavage, vitreous lustre, light pale green colour, and subtranslucency.

Phlogopite (composition variable approximately, silica 40, alumina 17, magnesia 27, potash 11, fluorine 2, water 3 per cent). Phlogopite, or amber mica, as far as was observed, is confined entirely to the large masses of serpentine in which it occurs in the form of finely disseminated flakes. It is a typical light amber variety quite similar in every respect to the phlogopite found in association with the contact pyroxenite in other parts of the same region.

Quartz (SiO_2). Masses of quartz were observed to be present in the magnesite deposits, at the north end of No. 1 outcrop on lot 15, range XI, Grenville; at the southwest end of the main pit on the McPhee property; and on the northwest margin of the pit opened by Messrs. Fitzsimmons and Boshart at the south end of lot 16, range IX, in Grenville township. It is possible that all of these occurrences are merely beds or masses of Grenville quartzite, since extensive outcrops of this rock adjoin the deposits.

Talc ($3MgO.4SiO_2.H_2O$: magnesia 31·7, silica 63·5, water 4·8 per cent). The talc found in associaton with the magnesite deposits is characterized by the waxy lustre and light greenish grey colour which usually characterize that mineral. It occurs chiefly with serpentine, filling fractures in the diopside masses.

Pyrite (FeS_2: iron 46·6, sulphur 53·4 per cent). Pyrite or iron pyrites occurs very commonly in the magnesite deposits in the form of irregular grains or cubes disseminated through the large serpentine masses and the dolomitic portions of the deposits. It is not generally present in the magnesite itself, nor in those portions of the deposits in which the proportion of dolomite is small.

Sphalerite (ZnS: zinc 67, sulphur 33 per cent). Sphalerite or zinc blende was observed at a few points in the magnesite deposits associated with the disseminated pyrite in the form of irregular, brownish-black grains. It has been found in abundance at only one point, namely, along the southeastern margin of the main pit on the McPhee property (lot 15, range IX, Grenville township). There, a lens of coarse grey dolomite, 100 feet long and 20 feet wide, occurs in which sphalerite intimately intergrown with pyrite is disseminated.

Magnetite (FeO: iron 72·4, oxygen 27·6 per cent). The presence of magnetite, magnetic iron oxide, was noted at a few points in the dolomitic portions of the magnesite deposits. It occurs in the form of octahedral grains up to one-half inch in diameter disseminated through the masses of coarsely crystallized dolomite.

Graphite (Carbon). Graphite is not commonly present in the magnesite deposits, but was observed to be finely disseminated through a zone of serpentinous dolomite-magnesite in the bottom of the main pit on the McPhee property.

ORIGIN.

The deposits of magnesite found throughout the world are all regarded as having originated in one or other of three ways. The Grecian magnesite deposits, most of the magnesite of California, and many other deposits found in various parts of the world, are believed to have been formed by the decomposition of serpentine, the serpentine in its turn being a decomposition product derived from olivine-pyroxene rocks (peridotites). The transformation of the serpentine is presumed to take place according to the following formula:

$$3MgO.2SiO_2.2H_2O+3CO_2=3MgCO_3+2SiO_2+2H_2O.$$

Magnesite deposits occurring near Bissel in California and in the valley of Muddy river near St. Thomas in Clark county, Nevada,[1] on the other hand, are said to be of sedimentary origin. The Austria-Hungarian deposits were also formerly thought to be of sedimentary origin, but are now generally regarded as the product resulting from the replacement of limestone by magnesian bearing solutions. A classification of the known deposits of magnesite according to genesis would, therefore, include:

(1) Deposits formed by the decomposition of serpentine.
(2) Sedimentary deposits.
(3) Deposits formed by replacement of limestone.

The study of the character and relationships of the Grenville magnesite deposits seems to indicate that these deposits belong to class 3 and are thus similar in origin to the Austria-Hungarian magnesite.

Decomposition of Serpentine. Since the Grenville magnesite deposits contain considerable serpentine, it might be presumed that the magnesite is an alteration product derived from the serpentine, and thus belongs genetically to the deposits of class 1. Magnesite deposits derived from serpentine, however, are generally characterized by the following features: (1) The serpentine is itself an alteration product derived from rocks of the peridotite family, (2) the magnesite occurs as veins or veinlets or irregular masses in the serpentine, and (3) the magnesite is usually traversed by veins of chalcedony and quartz. In the case of the Grenville magnesite deposits, on the other hand, there is no evidence anywhere in the district that peridotite was ever present in association with magnesite deposits, while there is much positive evidence indicating that the serpentine has originated by replacement of limestone in the manner described in section 3 below; the magnesite does not occur as veins traversing the serpentine, and except for a few isolated masses a few feet in diameter, quartz is entirely absent from the deposits. It is improbable

[1] Min. and Eng. World, vol. 44, 1916, p. 482.
Min. and Sc. Press, vol. 114, 1917, p. 238.

therefore, that the magnesite masses composing the Grenville deposits are directly related genetically to the serpentine with which they are associated.

Sedimentary Deposition. The rocks adjoining the magnesite deposits, in so far as they are exposed, consist in the main of quartzite, garnet gneiss, and crystalline limestone belonging to the Grenville series. The association of the magnesite with these metamorphosed sediments might, therefore, indicate that the deposits were of sedimentary origin; but the Grenville series originally consisted of interstratified beds of shale, sandstone, and limestone, sediments differing in no respect from well sorted marine deposits laid down during more recent geological periods; and, it is generally assumed on the basis of both geological and chemical evidence that magnesium carbonate would not be deposited in large masses under such conditions.[1]

However it has been suggested by Daly[2] that in Pre-Cambrian time conditions of marine deposition were strikingly different from those prevailing at a later stage in geological history, the ocean being nearly limeless. But the very existence of the Grenville series, which includes a large proportion of limestone, seems to disprove this hypothesis. The Grenville series had originally a minimum areal extent of at least 150,000 square miles and whether the thickness of nearly 18 miles assigned to the series in eastern Ontario by Adams and Barlow[3] be an excessive estimate or not, the wide extent of the series and the fact that the floor upon which the series was laid down has nowhere been observed seem to indicate that the thickness is at least many thousand feet. Furthermore, the Grenville series throughout the greater part of its extent has been intimately intruded by pyroxene gabbro, pyroxene diorite, anorthosite, and related rocks, by which the limestone member has been partly or completely metamorphosed to diopside, serpentine, phlogopite, and many other magnesian silicates; and the larger part of the analyses of Grenville limestone, contained in geological publications, has been made from specimens collected without regard to these geological relationships or the possibility that the magnesian content of the rock had been increased by contact metamorphism. Yet despite this random selection of material many of the analyses of Grenville limestone show the magnesia content to be less than 2 or 3 per cent.[4] It must be concluded, therefore,

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[1] Van Hise, C. R., U.S.G.S. Mon. 47, 1904, pp. 802, 808.

Clarke, F. W., "Data of Geochemistry," U.S.G.S., Bull. 491, 1911, pp. 534-545.

Johnston, J., "The solubility product constants of calcium and magnesium carbonate," Jour. Am. Chem. Soc., vol. 37, 1915, p. 2001.

Redlich, Karl A., Die Bildung des Magnesits und sein naturliches.

Vorkommen, Fortschritte der Min., Krist. und Petr. vol. 4, 1914. pp. 9-42.

[2] Bull. Geol. Soc. Am., vol. 20, 1909, pp. 153-170, Am. Jour. Sc., vol. 23, 1907, p. 93.

[3] Geol. Surv., Can., Mem. 6, 1910, p. 33.

[4] Miller, W. G. and Knight, C. W., "The Pre-Cambrian geology of southeastern Ontario," Bur. o Mines, Ont., 1914., pp. 21, 77, 86.

Frechette, H., Mines Branch, Dept. of Mines, Can., Sum. Rept., 1914, pp. 36-37.

that in so far as the deposition of magnesium carbonate is concerned, conditions of deposition in early Pre-Cambrian time in the Grenville district were probably not essentially different from those in more recent geological epochs, and, if this were the case, it is very improbable that the magnesite deposits are of sedimentary origin.

Replacement of Limestone. Among the more important data that might be cited in favour of the hypothesis that the magnesite contained in the Grenville magnesite deposits has been deposited by replacement of limestone are the following:

(1) In the section of the memoir in which the structure of the magnesite deposits was described, pages 26 and 27, it was pointed out that the magnesite was banded in places, the difference in the bands being partly due to difference in colour and partly to variations in the proportion of disseminated serpentine in different bands; but, the Grenville limestone commonly exhibits a banding strikingly similar to this, the only difference being that in the case of the limestone the disseminated grains in many places consist of diopside or partly serpentinized diopside as well as serpentine (Plate IX.[1]) The similarity of this phenomena in both the limestone and magnesite seems to indicate that there is, in some way, a close genetic connexion between the magnesite and the Grenville limestone.

(2) In numerous localities not only in the Grenville district but throughout a considerable part of the region in which the Grenville series is found, the crystalline limestone member of the series contains nodular masses of serpentine, or diopside partly altered to serpentine, which in some cases are several hundred feet in diameter. The presence of such masses in the limestone can scarcely be explained by any other hypothesis than that they have been formed from the limestone by silication.

(3) In many localities throughout the region in which the Grenville series is found, there are also extensive masses of rock generally known as "pyroxenite" with which the mica and apatite deposits of eastern Ontario and Quebec are associated. These masses are composed of diopside, scapolite, phlogopite, apatite, feldspar, quartz, calcite, tremolite, actinolite, serpentine, tourmaline, chabazite, stilbite, zircon, vesuvianite, and other minerals of similar character. It is believed from the association of these masses with limestone, from the abundance of lime silicate and pegmatitic minerals which they contain, and, from the high lime content of the deposits as a whole, that they have been formed from the limestone through the agency of pegmatitic magnesia-rich solutions.[2]

[1] The photograph reproduced as Plate IX was taken at the town of Buckingham, situated 50 miles to the west of the Grenville district, but exhibits a feature which can be observed almost everywhere in the Grenville limestone.

[2] Trans. Can. Min. Inst., vol. 19, 1916, pp. 349-370.
Geol. Surv., Can., Sum. Rept., 1915, pp. 156-168.

(4) In places masses of dolomite occur associated wit' · serpentine contained in the limestone, and in a few localities the dolomite can be seen to be distributed irregularly along fractures traversing the limestone.

(5) The rocks of the Grenville series have been intruded almost everywhere by bosses and thin *lit par lit* injections consisting of pyroxene gabbro, pyroxene diorite, pyroxene syenite, diorite pegmatite, and syenite-pegmatite, and it would, therefore, seem probable that the solutions by which the limestone was transformed into diopside and other minerals emanated from these intrusives.

(6) The association of diopside and phlogopite with the Grenville magnesite deposits indicates that there is a genetic relationship between the magnesite deposits, the masses of diopside and serpentine found in the limestone of the Grenville series, and the metamorphic "pyroxenite," and that they have all been formed in some way by the transformation or replacement of limestone.

On the whole, therefore, there is considerable positive evidence in support of the hypothesis that the magnesite deposits have been formed by the silication and replacement of Grenville crystalline limestone; and, on this assumption it is possible, from the character and relationships of the deposits, to outline approximately the manner in which this transformation took place.

The probable order of events by which the magnesite deposits of the Grenville district were formed was as follows: (1) silication of limestone to diopside and the formation of phlogopite in places, (2) formation of serpentine in places, (3) replacement of limestone by dolomite, (4) replacement of dolomite by magnesite, and (5) the alteration of diopside to serpentine.

As regards the origin of the serpentine associated with the magnesite deposits, it is difficult to determine whether this mineral replaced the lime: directly or indirectly through the alteration of diopside, and both o. ..ese possibilities have, therefore, been included as stages 2 and 5 in the formation of the magnesite deposits. In the case of the inclusions of serpentine, which occur associated with the Grenville limestone, there is direct evidence to indicate that the serpentine has been derived from diopside, but this transformation presumably takes place according to the following equation:

$$3CaMg\ (SiO_3)_2 + 3CO_2 + 2H_2O = 3MgO,\ 2SiO_2,\ 2H_2O + 4SiO_2 + 3CaCO_3$$

and should, therefore, be accompanied by the setting free of considerable quantities of quartz, whereas as far as was observed quartz is not present in association with the serpentine of the magnesite deposits.

From the occurrence of the dolomite as scattered inclusions in the magnesite, it would appear that the replacement of the limestone by magnesite was effected in a manner somewhat similar to that originally suggested by Redlich for the magnesite deposits of Austria-Hungary, namely, by two chemical reactions, dolomite being formed in the first reaction and the magnesite in the second.[1] The second reaction was not carried to completion, however, throughout the Grenville magnesite deposits and in consequence included remnants of dolomite remain disseminated through the magnesite.

The reactions according to Redlich were as follows:

(1) $CaCO_3 + MgCO_3 = MgCaCO_3 + CaCO_3$.
(2) $MgCaCO_3 + MgCO_3 = 2MgCO_3 + CaCO_3$.[2]

DETERMINATION OF LIME CONTENT OF MAGNESITE AND MAGNESITE-DOLOMITE.

Physical Characters. In mining the magnesite from the Grenville deposits it is customary to remove the dolomitic material as far as possible from the ore by cobbing; and, since in this operation the presence of the dolomite is determined only by such differences in appearance as distinguish magnesite from dolomite, the relationship of the lime content of the magnesite-dolomite to its physical character is of practical importance. From the determinations of the percentage of lime contained in the samples described in Tables I to VIII, the following general conclusions are inferred.

Cream-white, medium to fine-grained, glistening magnesite usually contains less than 7 per cent CaO.

Snow-white, medium or fine-grained glistening magnesite usually contains less than 11 per cent CaO.

Milk-white, medium or fine-grained glistening magnesite usually contains less than 12 per cent CaO.

Grey magnesite is generally more highly dolomitic than either cream-white, snow-white, or milk-white material, but there are a few striking exceptions to this rule.

Dull white material is dolomite and contains approximately 30 per cent CaO.

Coarsely crystalline material (that is, material exhibiting cleavage faces generally greater than one-fourth inch in diameter) is usually dolomite and contains approximately 30 per cent CaO.

Action of Concentrated Hydrochloric Acid. Since dolomite is much more soluble in hydrochloric acid than magnesite, the percentage of dolomite contained in the Grenville magnesite can also be approximately determined from the behaviour of the material when treated with cold concen-

[1] Tschermak's Mineralogishe Mitt. 1907, p. 499.

[2] Redlich has since modified his original suggestion with regard to the mode of origin of the Austro-Hungarian magnesite and now regards the replacement of limestone by magnesite as the first operation, and the formation of dolomite as the second.

trated hydrochloric acid. In practice it was found that the acid had usually no apparent effect on fine to medium-grained magnesite-dolomite in which less than 7 per cent of lime was present, that a feeble effervescence in widely separated spots occurred on magnesite-dolomite containing less than 12 per cent CaO, and that more than a feeble effervescence in widely separated spots indicated that the percentage of lime present was greater than 12 per cent. It was also found, however, that coarsely crystalline material did not effervesce as readily as fine-grained magnesite dolomite.

Calcination. The percentage of CaO contained in the magnesite-dolomite can also be approximately determined by means of the difference in colour of the magnesite and dolomite after the material has been calcined. Thus in the case of the cut face of the specimen of magnesite-dolomite shown in Plate VII B, the total area of the inclusions of dolomite amounts to approximately 8 per cent of the area of the whole face, and since dolomite contains approximately 30 per cent of CaO, the specimen contains approximately 2½ per cent CaO. This determination is probably within one-half per cent of the CaO content actually present, for the specimen shown in Plate VII B was selected as the best grade of material represented in area No. 117 on the McPhee property (lot 15, range IX, Grenville township), the lime content of which was determined by chemical analysis to be 3·93 per cent (Table VII, p. 55).

EXPLANATION OF TABLES AND OUTCROP MAPS.

For the purpose of determining the variation in quality, the extent, and the relationships of the magnesite and magnesite-dolomite contained in the Grenville deposits, the outcrop maps shown in Map 1679 were prepared by means of the plane-table, alidade, and chain. In preparing these maps, those parts of the outcrops underlain by magnesite and magnesite-dolomite were subdivided into numbered areas, material of the same physical character and quality being included as far as possible in the same area. From each of these areas average samples were procured by collecting chips from each square foot of surface. Since in practice, however, it is customary to remove serpentine and dolomitic material from the ore as far as possible by cobbing, cobbable material of this class was not included in the samples. The physical character and the lime content, etc., of the samples collected from the various areas are indicated in Tables I to IV, VI, and VII, accompanying the descriptions of the various properties.

In these tables, colour, lustre, grain, percentage of material cobbed, and composition of material cobbed are indicated. Under the heading grain, the magnesite is classified as fine, medium, or coarse, according as its grains are less than ⅛ of an inch, ⅛ to ¼ of an inch, or greater than ¼ of an inch in diameter, respectively.

In Tables V and VIII a summarized statement of the number of feet of magnesite, magnesite-dolomite, and serpentine contained in diamond drill cores obtained in lot 15, range XI, and lot 15, range IX, Grenville township, is included.

CHAPTER IV.

DESCRIPTIONS OF PROPERTIES.

GENERAL STATEMENT.

In the following chapter the deposits of magnesite and magnesite-dolomite so far discovered in the Grenville district are described and the tonnage of magnesite and magnesite-dolomite known to be present in each deposit estimated. A list of the lots on which the various deposits occur and of the owners of these lots is included in the following table:

List of Properties.

Lot	Range	Township	Owner
13	1	Harrington.	International Magnesite Co., Ltd.
18	11	Grenville.	North American Maghesite Co., Ltd.
15	11	"	Scottish Canadian Magnesite Co., Ltd.
15	10	"	" " " "
15	9	"	North American Magnesite Co., Ltd.
13	9	"	
16	9	"	Fitzsimmons and Boshart.
11	8, N	"	Campbell.
12	8, N	"	Fitzsimmons and Boshart.
11	8, S	"	"
12	8, S	"	"
9	11	Augmentation of Grenville.	
21	1	Harrington.	
77	10	Grenville.	

LOT 13, RANGE I, HARRINGTON TOWNSHIP, DOBBIE MINE.

The Dobbie magnesite mine, the property of the International Magnesite Company, lies near the north end of lot 13, range I, Harrington township, and near the eastern margin of the broad flat which adjoins Rouge river in the southwestern part of Harrington township.

The outcrop in which the magnesite is found has an areal extent of approximately 300 by 200 feet, but at the time the deposit was visited by the writer in January 1917, only an area 25 by 50 feet, where mining operations had been commenced, was visible through the heavy cover of snow. The part of the deposit being mined averaged 7·5 per cent CaO.[1] It consisted in part of glistening white magnesite and, in part, of medium to coarse-grained, grey material containing disseminated grains of dark green serpentine.

[1] According to analyses by J. T. Donald and Co. of Montreal.

A series of samples from an area about 100 feet square on the surface of the outcrop was collected and analysed by J. T. Donald and Company of Montreal and was found to carry the following lime content:

Sample No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Per cent CaO	6·58	7·72	10·45	7·26	7·72	11·19	10·68	7·94	4·77	10·68	15·77

Average omitting No. 11..................8·50

An average sample from a shipment of magnesite from the property was also found to have the following composition:[1]

Silica	1·60
Iron oxide and alumina	1·81
Lime	7·89
Magnesia	39·25
Loss on ignition	49·72

The quality and extent of the magnesite already known to be present on this property seem to indicate that the quantity of ore actually present may be extensive, but much development work is required before this can be positively determined. All that can be stated at present with regard to the deposits is that, on the basis of certain assumptions inferred from the study of the magnesite deposits as a whole, it is calculated that at least 25,000 tons of magnesite ore is present. The data on which this estimate is based are as follows:

Known horizontal extent of deposit, 10,000 square feet.
Assumed depth, 50 feet.
Assumed proportions of magnesite present in deposit, 60 per cent.
Number of cubic feet of magnesite in one ton, 12.

Accompanying the magnesite there is also probably present at least 8,000 tons of magnesite-dolomite.

A number of camp buildings have been erected on the property.

LOT 18, RANGE XI, GRENVILLE TOWNSHIP, SHAW MINE.

This property is situated at a distance of approximately 15 miles from the Canadian Pacific railway, and, on this account, is operated only in the winter, when the cost of transportation to the railway by sleigh is $2.50 per ton as compared with a cost of $4.50 in the summer. At the time the outcrop was examined by the writer in July 1916, the surface of the magnesite was so covered by broken rock, left at the close of the previous winter's operation, that magnesite in place could not be seen except along the southern face of the pit and in a low ledge projecting through the rock debris near the north end of the deposit.

The rock outcrop in which the magnesite is found originally formed a low northeasterly trending ridge, but it has been excavated down to the same elevation as the surrounding flat except at its south end where a face from 10 to 20 feet high remains, out of which an extension of the

[1] According to analyses by J. T. Donald and Co., of Montreal.

main pit from 15 to 20 feet wide has been excavated southward for a distance of 50 feet. A diagrammatic section across the face of this extension is shown in Figure 2. It is stated by Mr. Broadbent, who examined the deposit in 1900, that the magnesite is intersected by a small dyke of porphyrite.[1] This dyke was not observed in place by the writer, but a number of fragments of black aphanitic diabase porphyry were observed on the dumps which were probably derived from the intrusion referred to by Mr. Broadbent.

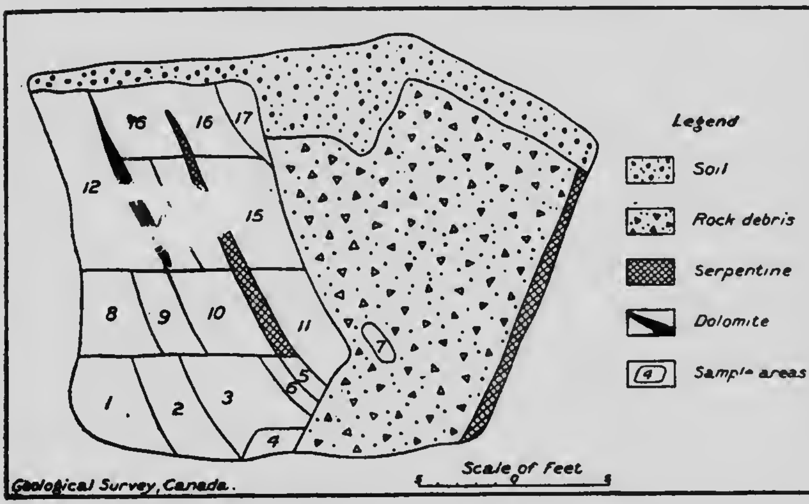


Figure 2. Diagrammatic section across south face of pit in magnesite deposit, lot 18, range XI, Grenville township.

Descriptions of the physical characters and the chemical analyses of samples from the magnesite deposit on the Shaw property are included in Table I. Samples Nos. 1 to 17 were collected from areas on the south face of the southern extension of the main pit as shown in Figure 2. Sample 18 was taken from a mass of magnesite exposed near the north end of the eastern face of the southern extension of the main pit, and samples 19 to 22 were taken from the projecting ledge of magnesite exposed near the north end of the deposit. Sample 23 represents the average of a small pile of ore remaining in the middle of the pit. The remaining samples (Nos. 24-35) were collected from the surface of the outcrop by Mr. Broadbent in 1900 and were described by him in the report of the section of chemistry of the Geological Survey for that year.

[1] Geol. Surv., Can., Ann. Rept. vol. XIII, 1900, pt. R, p. 15.

Since the Shaw property was examined by the writer a single diamond drill hole has been drilled on the property to a depth of 64 feet with the following result:

Number of feet containing less than 13 per cent CaO	Number of feet containing more than 13 per cent CaO	Number of feet of serpentine.
23½	23	17½

At a depth of 35 feet a marked increase in the per cent of lime occurred in this core, but this may possibly be due to the fact that a lens of dolomitic material was encountered at this point.

Owing to the poorly exposed condition of the magnesite deposits at the time it was examined, and the absence, except for the single drilling record, of information with regard to the depth to which the deposit extends, the data necessary for even an approximate estimate of the total tonnage of magnesite present on the Shaw property are not available; but, on the basis of certain minimum assumptions, an estimate of the approximate number of tons of magnesite in sight can be obtained. The data on which such an estimate can be based are the following:

Approximate superficial extent of deposit, 15,000 square feet.
Assumed average depth to which deposit extends, 25 feet.
Proportion of magnesite averaging 10 per cent CaO in deposit, 50 per cent.
Proportion of magnesite averaging 16 per cent CaO in deposit, 20 per cent.
Proportion of serpentine in deposit, 30 per cent.

From the preceding information it can be calculated that there is present in the deposit approximately 15,000 tons of magnesite averaging 10 per cent lime and 6,000 tons of material averaging 16 per cent lime.

It is, of course, possible that the deposit extends to a greater depth than 25 feet; but, in view of the results obtained from the single hole drilled, a greater depth could not be safely assumed in making a definite estimate of the tonnage. Similarly, it is possible that the superficial extent of the deposit may eventually prove to be greater than 15,000 square feet, but further development work is required before this can be determined. The percentages of serpentine and magnesite present in the deposit were determined partly from the information contained in Table I and partly from the known general character of the magnesite deposits of the district as a whole.

A two-story camp building having accommodation for about twenty men has been erected on the property.

Table I. Physical Character and Chemical Composition of Samples of Magnesite from Outcrop on North Half of Lot 18, Range XI, Grenville Township.

No.	Colour	Lustre	Grain	CaO	MgO	Equivalent to $CaCO_3$	Equivalent to $MgCO_3$	Silica and insoluble matter.
1	snow-white.......	glistening ...	fine.........	8·77	40·28	15·60	84·18	0·50
2	snow-white.......	glistening....	fine.........	6·83	40·48	12·20	84·60	2·90
3	snow-white.......	glistening....	fine.........	7·96	40·66	14·21	84·98	0·88
4	white............	dull.........	fine.........	14·90	34·38	26·60	71·86	2·16
5	white............	glistening....	fine.........	11·87	31·82	21·20	66·50	22·00
6	blue-grey........	dull.........	fine.........	11·96	38·02	21·35	79·26	0·10
7	snow-white.......	glistening....	medium.....	11·25	37·78	20·40	78·96	1·50
8	snow-white.......	glistening....	medium.....	12·18	35·70	21·78	74·61	6·10
9	white............	dull.........	fine to medium	8·33	39·40	14·87	82·34	2·32
10	white............	glistening....	medium to coarse	14·31	35·74	25·55	74·70	0·50
11	white............	glistening....	fine.........	0·87	37·02	1·55	77·[illegible]8	26·40
12	white............	glistening to dull	medium granulated	11·17	37·36	19·94	78·08	2·20
13	white............	glistening....	medium.....	9·80	35·08	17·50	73·32	28·04
14	grey.............	dull.........	fine.........	15·86	33·08	28·32	69·14	2·00
15	white............	dull........	granulated ..	9·95	37·94	17·77	79·30	2·38
16	white............	dull.........	fine compact .	10·48	36·46	18·71	76·20	3·30
17	snow-white.......	glistening....	medium.....	10·44	37·60	18·64	78·58	0·90
18	cream-white......	dull.........	fine compact.	8·58	39·56	15·32	82·64	0·80
19	pink.............	dull to glistening	fine.........	11·76	36·10	21·00	75·44	2·24
20	cream-white......	dull to glistening	fine.........	17·50	32·12	31·25	67·12	0·64
21	snow-white.......	dull.........	fine to medium	16·98	29·60	30·32	62·20	11·40
22	snow-white.....	glistening....	fine.........	6·45	40·54	11·52	84·72	2·36
23	Average sample from ore pile...		....	10·16	38·02	18·14	79·46	1·84
24	blue-white.......	....	coarsely crystalline	9·00	37·35	16·07	77·62	
25	blue-white.......	....	fine.........	10·58	33·45	18·89	74·68	
26	milk-white.......	....	fine.........	8·75	38·17	15·57	78·08	
27	milk-white.......	....	fine.........	6·04	36·73	10·78	77·16	
28	blue-white.......	....	fine.........	8·96	36·22	16·00	76·09	
29	grey to reddish white	....	fine.........	7·36	36·61	13·14	76·97	
30	greyish-white.....	....	fine.........	[illegible]·88	23·66	30·14	49·71	
31	greyish-white and reddish-white	....	fine to coarse	[illegible]4	[illegible]·93	19·71	75·69	
32	grey-white.......	....	coarse.......	[illegible]	39·36	12·36	82·72	
33	blue-white translucent	....	medium	6·[illegible]	40·46	10·80	85·00	
34	snow-white subtranslucent	....	medium.....	small percentage	45·36	....	95·50	
35	Average sample from surface of outcrop		.....	9·12	36·68	16·28	77·07	

Analyses 1–23 by Mr. H. A. Leverin of the Mines Branch, Department of Mines, Ottawa.
Analyses 24–34 by Mr. F. G. Wait, Geol. Surv., Can., Ann. Rep., 1900, pt. R, pp. 14–17.

LOT 15, RANGE XI, GRENVILLE TOWNSHIP.

On this lot a series of three exposures of magnesite, magnesite-dolomite, and serpentine, occur along the eastern margin of the flat which extends southward from Grenville lake at the south end of the lot. These outcrops numbered from south to north are known as Nos. I, II, and III respectively. The descriptions of the physical character and lime content of samples from the surface of these outcrops have been tabulated in Tables II to IV, while the proportions of magnesite, magnesite-dolomite, and serpentine contained in diamond drill cores obtained in drilling operations on the property by the Harbison-Walker Refractories Company of Pittsburg are summarized in Table V.

Outcrop No. I.

Magnesite of No. 1 quality is known to occur along the southern and southwestern margin of this outcrop, and in the vicinity of diamond drill hole No. 15. A summation of the proportions of magnesite, magnesite-dolomite, and serpentine exposed in the southwestern portion of the deposit (outcrop No. I, and table II) is as follows:

	Per cent.
Magnesite..............................	62
Magnesite-dolomite....................	8
Serpentine.............................	30

A similar summation for the diamond drill cores obtained in this area and from hole No. 15 (see table V) is as follows:

	Per cent.
Magnesite..............................	66
Magnesite-dolomite....................	12
Serpentine.............................	22

It can be safely assumed, therefore, that in these portions of the outcrop the proportion of magnesite containing less than 12 per cent lime is at least 60 per cent. From the examination of the various deposits in the district it is inferred that, as a rule, the quality of the material obtained from a drill hole will be maintained horizontally for a distance of at least one-fourth the depth of the hole in either direction along the strike of the deposit and one-eighth the depth of the hole in either direction at right angles to the strike.

On the basis of these assumptions the following data are available from which the number of tons of magnesite in sight in No. I outcrop can be estimated:

Superficial area of deposits adjacent to diamond drill holes Nos. 11, 8, and 10, 4,800 square feet.

Proved depth to which deposit descends in area adjacent to drill holes Nos. 11, 8, and 10, 50 feet.

Total horizontal extent of deposits adjacent to diamond drill holes Nos. 12, 13, 20, and 15, 20,000 square feet.

Proved average depth to which deposit descends in the vicinity of diamond drill holes, Nos. 12, 13, 20, and 15, 180 feet.

Proportion of magnesite containing less than 12 per cent CaO in deposit, 60 per cent.

Proportion of magnesite-dolomite in deposit, 10 per cent.

Number of cubic feet of magnesite in 1 ton, 12.

The tonnage of material present in the deposit is, therefore, as follows:

	Magnesite.	Magnesite-dolomite
Adjacent to drill holes Nos. 11, 8, and 10...	12,000 tons	2,000 tons.
Deposits in the vicinity of holes Nos. 12, 13, 20, and 15......................	180,000 tons	30,000 tons
Total........................	192,000 tons	32,000 tons.

In those parts of No. I outcrop not included in the above estimate there is exposed approximately 7,000 square feet of rock surface composed as follows:

Magnesite, 8 per cent.
Magnesite-dolomite, averaging 16 per cent CaO, 62 per cent.
Serpentine, diopside, and quartz, 30 per cent.

Most of these areas are scattered over the surface of the outcrop, and it is only in the vicinity of diamond drill hole No. 18 that a mass of magnesite-dolomite of workable dimensions is known to occur. At this point approximately 5,000 tons of magnesite-dolomite are present.

Table II. Physical Character and Lime Content of Samples of Magnesite from Outcrop No. I, Lot 15, Range XI, Grenville Township.

No.	Colour	Lustre	Grain	Per cent of cob.	Material cobbed	Per cent of CaO	Per cent of CaO in material cobbed[3]
1	rusty-white	shining	coarse	nil	....	22·00[1]	
2	white-grey	glistening	fine	25	grey magnesite-dolomite	9·66[2]	15·00
3	white	dull to glistening	coarse	nil	....	22·00[1]	
4	snow-white and cream-white	glistening	fine	nil	....	9·00[1]	
5	white	shining-dull	coarse to fine	nil	....	18·00[1]	
6	snow-white	glistening	fine	nil	....	9·00[1]	
7	snow-white to grey	glistening	fine	40	coarse white dolomite	10·00[2]	24·00
8	cream white	glistening	fine	nil	....	7·00[2]	
9	cream white	glistening	fine	nil	....	6·96[2]	
10	white to grey	glistening	fine to medium	25	grey magnesite-dolomite	13·00[2]	18·00
11	cream white to snow-white	glistening and shining	fine and coarse	20	coarse white dolomite	12·00[1]	26·00
12	white	shining	coarse	nil	....	13·00[1]	
13	grey to white	dull to shining	fine to coarse	nil	....	20·00[1]	
14	white to grey	glistening	fine	nil	....	14·26[2]	
15	grey-white	glistening	fine	nil	coarse white dolomite	19·90[2]	28·00
16	grey-white	glistening	fine	nil	....	13·35[2]	
17	grey-white	glistening	fine	nil	....	14·00[1]	
8	snow-white	glistening	fine	nil	....	13·00[1]	
9–21	grey	glistening to dull	fine	nil	....	15·00[1]	
2	grey	glistening to dull	fine	20	dull white dolomite	13·73[2]	29·00
3–24	grey	dull to glistening	fine	nil	....	15·00[1]	
5	white to grey	glistening to dull	medium	20	serpentine	11·66[2]	
6	milk-white to grey	glistening to dull	fine to medium	nil	....	13·00[2]	
7	white to grey	glistening and dull	medium	10	serpentine	12·00[1]	
8	grey-white	glistening	fine	nil	....	11·00[2]	
9	white	dull to glistening	medium to coarse	nil	....	18·00	
0	snow-white	glistening	fine	20	yellow serpentine	13·00[1]	
1	white	shining	medium to coarse	nil	....	18·00[1]	
2	milk-white to snow-white	glistening to shining	medium to coarse	10	....	19·30[2]	
[illegible]	grey	shining	coarse	nil	....	22·00[1]	
[illegible]	snow-white to milk-white	glistening to dull	fine	50	serpentine	11·00[1]	
[illegible]	grey-white	dull	fine	nil	....	15·00[1]	
[illegible]	snow-white	glistening	fine	nil	....	9·00[1]	
[illegible]	snow-white	glistening	fine	nil	....	12·00[1]	
[illegible]	white	dull to shining	medium to coarse	nil	....	20·00[1]	
[illegible]	snow-white and milk-white	glistening	fine	5	dull white and grey dolomite	9·74[2]	
[illegible]	speckled grey	shining to dull	coarse	nil	....	21·30[2]	
[illegible]	snow and milk-white	glistening	fine	25	serpentine	11·00[1]	
[illegible]	snow-white	glistening	fine	nil	....	8·00[1]	
[illegible]	snow-white	glistening	fine	nil	....	4·64[2]	

Table II.—Continued.

No.	Colour	Lustre	Grain	Per cent of cob.	Material cobbed	Per cent of CaO	Per cent of CaO in material cobbed[1]
44	grey to snow-white......	glistening to dull..	fine.......	25	serpentine..........	12·00[1]	
45	speckled grey..........	glistening........	medium...	50	serpentine..........	19·00[1]	
46	snow-white............	glistening........	fine.......	5	serpentine..........	7·00[1]	
47	grey.................	glistening........	medium...	25	serpentine..........	14·00[1]	
48	snow-white to blue grey	glistening........	fine.......	nil	....	8·00[1]	
49	grey to snow-white......	glistening........	fine.......	nil	....	9·00[1]	
50	snow-white to grey......	glistening........	fine.......	nil	....	9·00[1]	
51	snow-white............	glistening........	fine.......	nil	....	7·00[1]	
52	grey to snow-white......	glistening........	fine.......	nil	....	8·14[1]	
53	snow-white............	glistening........	fine.......	25	serpentine..........	10·00[1]	
54	snow-white............	glistening........	fine.......	nil	....	5·00[1]	
55	grey.................	glistening........	medium...	5	serpentine..........	13·00[1]	
56	snow-white............	glistening........	fine.......	nil	....	8·86[2]	
57	grey to snow-white......	glistening........	medium...	50	coarsely crystalline white dolomite	10·00[1]	28·00
58	snow-white to milk-white	glistening........	fine.......	10	green serpentine....	9·00[1]	
59	snow-white............	glistening........	fine.......	5	coarsely crystalline white dolomite	7·00[1]	27·00
60	speckled grey..........	shining to dull....	medium...	nil	....	14·00[1]	
61	speckled grey..........	glistening to dull..	fine.......	nil	....	16·00[1]	
62	grey.................	glistening........	medium to coarse	nil	....	17·00[1]	
63	grey.................	dull to glistening	medium to coarse	nil	....	14·00[1]	
64	white................	shining..........	medium...	nil	....	16·00[1]	
65	speckled grey..........	dull to shining....	fine to coarse	nil	....	15·00[1]	
96	grey and snow-white.....	glistening and shining	fine and coarse	nil	....	15·[illegible]	
67	grey.................	glistening........	medium...	nil	....	14·00[1]	
68	grey.................	glistening to shining	medium to coarse	25	serpentine..........	13·00[1]	
69–71	grey to white..........	dull to glistening..	medium to coarse	nil	....	16·00[1]	
72	white and speckled grey	glistening........	medium...	25	coarse dolomite.....	11·00[1]	25·00
73	grey.................	dull to glistening	fine.......	nil	....	14·00[1]	
74	white to grey..........	glistening to shining	fine.......	nil	....	13·00[1]	
75	snow-white............	glistening........	fine.......	nil	....	10·76[2]	
76	snow-white............	glistening........	fine.......	25	serpentine..........	11·00[1]	
77	snow-white............	glistening........	fine.......	30	serpentine..........	11·00[1]	
78	snow-white............	glistening........	fine.......	5	serpentinous dolomite-magnesite	7·16[2]	16·00
79	snow-white............	glistening........	fine.......	20	green serpentine....	10·00[1]	
80	snow-white............	glistening........	fine.......	10	green serpentinous material	10·00[1]	15·00
81	Average sample from pile of ore (containing approximately 900 tons) excavated from sample areas 75–81........				....	8·74[2]	
82	Average sample from pile of ore (containing approximately 1,000 tons) excavated from sample area 82..................				....	9·92[2]	

[1] Estimated.
[2] Determined by Miss D. M. Stewart, Mines Branch, Department of Mines.

Outcrop No. II.

Magnesite and magnesite-dolomite are known to occur in this outcrop at four points. (See map 1679 and Tables III and V). On the basis of assumptions similar to those made in the case of No. I outcrop, the number of tons of magnesite and magnesite-dolomite in sight in each of these localities is estimated as follows:

Locality	Tons of magnesite.	Tons of magnesite-dolomite.
Adjacent to diamond drill hole No. 23.......	9,000	1,500
Adjacent to diamond drill holes, Nos. 22, 24, and 25............................	27,500	17,000
Adjacent to diamond drill holes Nos. 27 and 28	2,500	200
Total.........................	39,000	18,700

Table III. Physical Character and Lime Content of Samples of Magnesite from Outcrop No. 11, Lot 15, Range XI, Grenville Township.

No.	Colour	Lustre	Grain	Per cent cob.	Material cobbed	Per cent CaO	Per cent of CaO in material cobbed
1	grey	dull	fine	nil		20·00[1]	
2	snow-white to milk-white	glistening	fine	20	serpentine	10·00[1]	
3	white to grey	glistening and dull	fine	nil	dull white serpentinous material	13·00[1]	
4	snow-white	glistening	fine	50		11·00[1]	22·00
5	snow-white to grey	glistening	fine	nil		10·00	
6	snow-white to grey	glistening	fine	20	serpentine	12·00	
7	snow-white	glistening	fine granulated	2	grey magnesite dolomite	14·70[2]	15·00
8	snow-white	glistening	fine	nil		11·00[1]	
9	average sample from pile of ore excavated from pit at 9					9·35[2]	
10	snow-white	glistening	fine	nil		9·00	
11	snow-white	glistening	fine	nil	serpentine	10·37[2]	
12	grey	dull	fine	nil		16·00[1]	
13	snow-white	glistening	fine	50	grey magnesite-dolomite	11·00[1]	14·00
14	snow-white	glistening	fine	2	grey magnesite-dolomite	13·49[2]	14·00
15	snow-white	glistening	fine	10	magnesite-dolomite	9·00[1]	13·00
16	snow-white	glistening	fine to medium	20	dull grey magnesite-dolomite	12·00[1]	15·00
17	snow-white	glistening	fine	5	dull grey dolomite	11·00[1]	20·00
18	snow-white	glistening	fine	nil		12·00[1]	
19	snow-white	glistening to shining	medium	nil		11·42[2]	
20	grey	glistening	fine to medium	nil		12·00[1]	
21	grey and pink	glistening to dull and shining	fine to medium	25	coarse grey magnesite-dolomite	10·00[1]	15·00
22	snow-white	glistening	fine	25	grey magnesite-dolomite	9·18[2]	14·00
23	snow-white	glistening	fine	nil		10·00[1]	
24	snow-white	glistening	fine	75	coarse grey magnesite-dolomite	9·00[1]	15·00
25	grey and snow-white	glistening	fine	50	grey magnesite-dolomite	10·00[1]	15·00
26	grey	shining and glistening	medium to fine	25	grey magnesite-dolomite	13·00[1]	16·00
27	snow-white to milk-white	shining and glistening	medium	40	grey magnesite-dolomite	9·00[1]	14·00
28	white	shining	medium to coarse	nil		13·00[1]	
29	snow-white	glistening	fine	nil		10·00[1]	
30	snow-white	glistening	fine	2	coarsely crystalline magnesite-dolomite	9·78[2]	15·00
31	snow-white	glistening	fine	nil		7·00[1]	
32	snow-white	glistening	fine	nil		8·00[1]	
33	snow-white	glistening	fine	5	grey magnesite-dolomite	13·00[1]	
34	snow-white	glistening	fine	nil		9·00[1]	
35	snow-white	glistening	fine	10	grey magnesite-dolomite	10·00[1]	14·00
36	snow-white	glistening	fine granulated	nil		7·00[1]	
37	snow-white	glistening	fine granulated	nil		9·00[1]	
38	snow-white	glistening	fine	50	dull white dolomite	7·00[1]	24·00
39	cream-white	glistening	fine	40	grey magnesite-dolomite	9·00[1]	15·00
40	cream-white and grey	glistening	fine	50	grey magnesite-dolomite	9·00[1]	15·00
41	white and grey	glistening	fine	25	grey magnesite-dolomite	13·00[1]	14·00
42	cream-white and grey	glistening	fine	50	grey magnesite-dolomite	8·68	13·00
43	cream-white and grey	glistening	fine	5	grey magnesite-dolomite	9·00[1]	13·00
44	snow-white	glistening	fine	5	grey magnesite-dolomite	10·00[1]	14·00
45	grey to cream-white	glistening	fine	30	serpentine	12·00[1]	

[1] Estimated.
[2] Determined by Miss D. M. Stewart, Mines Branch, Department of Mines.

The data from which the above estimates were made follow:

Deposit adjacent to drill hole 23.

Horizontal extent, 2,100 square feet.
Proved depth, 90 feet,
Composition: magnesite, 60 per cent; magnesite-dolomite, 10 per cent; serpentine, 30 per cent.

Deposit adjacent to diamond drill holes, Nos. 22, 24, and 25.

Horizontal extent, 6,500 square feet,
Proved average depth, 135 feet,
Composition: magnesite, 40 per cent; magnesite-dolomite, 25 per cent; serpentine, 35 per cent.

Deposits adjacent to diamond drill holes Nos. 27 and 28.

Horizontal extent hole 27, 600 square feet, and hole 28, 600 square feet.
Proved depth, 50 feet,
Composition: magnesite, 50 per cent; magnesite-dolomite, 5 per cent; serpentine, 45 per cent.
Number of cubic feet of magnesite and magnesite-dolomite in 1 ton, 12.

Unexposed Area Between Outcrops II and III.

In the unexposed area between outcrops II and III there are three diamond drill holes (see table V) which have disclosed the presence of approximately 90,000 tons of magnesite-dolomite.

The data on which this estimate is based follow:

Horizontal extent, 20,000 square feet.
Proved depth, 80 feet.
Composition: magnesite-dolomite, 70 per cent; serpentine, 30 per cent; number of cubic feet of magnesite-dolomite in 1 ton, 12.

Outcrop No. III.

There is exposed in outcrop No. III (see outcrop III on Map 1679 and Table IV), approximately 25,000 square feet of rock surface composed as follows:

Magnesite, 65 per cent,
Magnesite-dolomite, 15 per cent,
Serpentine, 30 per cent.

The eight drill cores Nos. 1 to 7 and 29, obtained from diamond drill holes in the deposit and its vicinity (see Table V), are composed as follows:

Magnesite, 60 per cent,
Magnesite-dolomite, 13 per cent,
Serpentine, 27 per cent.

In calculating the number of tons of magnesite and magnesite-dolomite present in No. 3 outcrop it can be assumed, therefore, that the deposit as a whole contains at least 60 per cent magnesite, and 13 per cent magnesite-dolomite.

Since diamond drill hole No. 29 was drilled in the clay flat outside the outcrop the horizontal extent of the magnesite ore known to be present in outcrop No. III can be enlarged to include the material in the vicinity of this drill hole.

On the basis of the foregoing deductions the following data are available from which the number of tons of magnesite and magnesite-dolomite in sight in outcrop No. III and its vicinity can be estimated:

Horizontal extent, 30,000 square feet.
Proved average depth, 125 feet.
Proportion of magnesite, 60 per cent.
Proportion of magnesite-dolomite, 13 per cent.
Number of cubic feet of magnesite and magnesite-dolomite in 1 ton, 12.

The tonnage of magnesite and magnesite-dolomite in the deposit is therefore, as follows:

Magnesite, 187,500 tons.
Magnesite-dolomite, 40,600 tons.

The preceding estimates of the tonnages of magnesite and magnesite-dolomite present on lot 15, range XI, Grenville, stated in summarized form are as follows:

	Magnesite tons	Magnesite-dolomite. tons
Number I outcrop	192,000	37,000
Number II outcrop	39,000	18,700
Between outcrops II and III	......	90,000
Number IV outcrop	187,000	40,600
Total	418,000	186,300

Table IV. Physical Character and Lime Content of Samples of Magnesite from Outcrop No. 111, Lot 15, Range XI, Grenville Township.

No.	Colour	Lust	Grain	Per cent of cob	Material cobbed	Per cent CaO	Per cent CaO in material cobbed[1]
1	cream-white, snow-white, and grey	glistening...	fine.......	20	grey magnesite-dolomite	5·00[1]	13·00
2	pink, cream-white, and grey	glistening ...	[illegible]	25	grey magnesite-dolomite	7·00[1]	13·00
3	cream-white and snow-white, grey	glistening ...	[illegible]	50	grey magnesite-dolomite	8·00[1]	13·00
4	grey..................	glistening	fine to medium	nil	....	16·00[1]	....
5	cream-white, snow-white, and grey	glistening	[illegible]	40	grey and dull magnesite-dolomite	9·00	12·00
6	cream-white and snow-white	glistening	fine	20	grey magnesite-dolomite	5·95[2]	12·00
7	pink, cream-white, and grey	glistening .	[illegible] medium	15	grey serpentinous magnesite-dolomite	6·00[1]	12·00
8	white................	shining	[illegible] to medium	[illegible]	serpentine..........	12·00[1]	....
9	cream-white and snow-white	glistening	[illegible]	nil	....	8·52[2]	....
10	cream-white, pink, and snow-white	glistening	[illegible]	nil	....	6·00[1]	....
11	cream-white and snow-white	glistening	[illegible]	40	coarsely crystallized and grey magnesite-dolomite	7·00[1]	14·00
12	cream-white and snow-white	glistening.	fine	5	grey serpentinous magnesite-dolomite	8·00[1]	12·00
13	snow-white to cream-white	glistening	fine......	10	grey and coarsely crystallized magnesite-dolomite	7·00[1]	12·00
14	cream-white to milk-white	glistening........	fine.......	nil	....	5·25[2]	....
15	cream-white to snow-white................	glistening........	fine.......	nil	....	6·00[1]	....
16	snow-white and milk-white	glistening........	fine.......	40	grey and coarse magnesite-dolomite	3·00[1]	13·00
17	snow-white and grey.....	glistening........	fine.......	10	coarse and grey magnesite-dolomite	8·00[1]	14·00
18	snow-white to grey.....	glistening........	fine.......	50	coarse, dull-white and grey magnesite-dolomite	8·57[2]	16·00
19	snow-white to grey......	glistening........	fine.......	50	coarse, dull-white and grey magnesite-dolomite	9·00[1]	17·00
20	grey..................	glistening and dull	fine.......	50	light green serpentine	13·00[1]	....
21	grey..................	glistening to dull..	fine.......	25	light green serpentine	12·00[1]	....
22	pink to grey...........	glistening........	fine.......	10	grey magnesite-dolomite	9·00[1]	13·00
23	cream-white to milk-white and grey	glistening........	fine.......	10	grey magnesite-dolomite	9·00[1]	13·00
24	snow-white to grey......	glistening........	fine.......	25	dull grey magnesite-dolomite	10·00[1]	15·00
25	grey to snow-white......	dull to glistening..	fine.......	50	grey magnesite-dolomite 25%, yellow serpentine 25%	14·00[1]	18·00
26	snow-white to grey......	glistening........	fine.......	35	grey magnesite-dolomite 15%, serpentine 20%........	12·00[1]	15·00
27	snow-white to milk-white	glistening........	fine.......	nil	....	10·88[2]	....
28	snow-white............	glistening........	fine.......	5	coarse and grey magnesite-dolomite	10·00[1]	14·00
29	snow-white............	glistening........	fine.......	20	coarse, shining, and dull-white magnesite-dolomite	11·00[1]	14·00
30	grey..................	glistening to dull..	fine.......	25	serpentine..........	15·00[1]	....
31	milk-white to grey......	glistening to dull..	fine.......	nil	....	14·59[2]	....
32	snow-white to milk-white	glistening...	fine.......	5	dull white and shining magnesite-dolomite	10·00[1]	18·00
33	snow-white to milk-white	glistening........	fine to medium	5	coarse dolomite.....	10·00[1]	25·00
34	snow-white and milk-white	glistening........	fine.......	25	coarse, dull-white, and grey magnesite-dolomite	11·00[1]	15·00

Table IV.—Continued.

No.	Colour	Lustre	Grain	Per cent of cob.	Material cobbed	Per cent of CaO	Per cent of CaO in material cobbed[1]
35	snow-white to milk-white	glistening	fine	60	coarse, shining, dull-white, and grey magnesite-dolomite	10·00[1]	18·00
36	snow-white	glistening	fine	5	coarse, shining, and grey magnesite-dolomite	11·00[1]	15·00
37	snow-white and red	glistening	fine	25	coarse, shining, and grey magnesite-dolomite	9·00[1]	14·00
38	grey	glistening and shining	fine to coarse	25	....	14·00[1]	....
39	speckled grey	glistening and shining	fine and coarse	nil	....	13·41[1]	....
40	cream-white, milk-white, and grey	glistening and shining	fine to coarse	5	dull-white dolomite	13·00[1]	22·00
41	cream-white to snow-white	glistening	fine	5	serpentine	6·00[1]	....
42	snow-white and milk-white	glistening	fine	nil	....	8·17[2]	....
43	snow-white and grey	glistening	fine	25	dull-white magnesite-dolomite	9·00[1]	17·00
44	grey	dull to glistening	fine to medium	nil	....	14·00[1]	....
45	snow-white	glistening	fine	nil	....	10·00[1]	....
46	snow-white to grey	glistening	fine	nil	....	10·72[2]	....
47	snow-white, milk-white, grey, and pink	glistening	fine	nil	....	10·00[1]	....
48	snow-white and milk-white	glistening	fine	nil	....	9·00[1]	....
49	snow-white and grey	glistening	fine	45	coarse dolomite 25%, serpentine 20%	12·00[1]	20·00
50	snow-white	glistening	fine	nil	serpentine	12·00[1]	....
51	snow-white, milk-white, and grey	glistening	fine	20	coarse, grey magnesite-dolomite	9·00[1]	18·00
52	snow-white, milk-white, and grey	glistening	fine	nil	....	10·00[1]	....
53	snow-white	glistening	fine	nil	....	9·62[2]	....
54	snow-white	glistening	fine	nil	....	9·37[2]	
55	snow-white, milk-white, and grey	glistening	fine	25	coarse, grey, serpentinous magnesite-dolomite	10·00[1]	15·00
56	milk-white and grey	glistening	fine	25	serpentine	9·00[1]	
57	milk-white and grey	glistening	fine	nil	....	10·00[1]	
58	snow-white	glistening	fine	60	grey magnesite-dolomite	10·00[1]	15·00
59	grey	glistening	fine	nil	....	13·00[1]	
60	snow-white and milk-white	glistening	fine	nil	....	10·64[2]	....
61	snow-white and milk-white	glistening	fine	nil	....	9·00[1]	
62	milk-white and grey	glistening and dull	fine	nil	....	11·84[2]	
63	snow-white	glistening	fine	nil	....	11·00[1]	
64	milk-white	glistening to shining	medium to coarse	nil	....	13·59[2]	
65	milk-white and grey	glistening	fine to medium	5	dark green serpentine	13·00[1]	
66	snow-white and milk-white	glistening	fine	nil	....	7·07[2]	
67	snow-white	glistening	fine	nil	....	7·00[1]	
68	snow-white and milk-white	glistening	fine	nil	....	8·56[2]	
69	snow-white and milk-white	glistening and shining	fine to medium	25	coarse, grey, and serpentinous magnesite-dolomite	9·00[1]	16·00
70	milk-white	glistening and shining	fine to medium	5	serpentine	10·00[1]	
71	snow-white	glistening	fine	75	grey, serpentinous magnesite-dolomite	10·00[1]	17·00

[1] Estimated.
[2] Determined by Miss D. M. Stewart, Mines Branch, Department of Mines.

Table V. Summary Description of Diamond Drill Cores from Magnesite Deposits on Lot 15, Range XI, Grenville Township.

No. of hole	Depth of soil feet	Magnesite containing less than 12 per cent CaO[1], feet	Magnesite-dolomite containing more than 12 per cent CaO[1], feet	Serpentine and diopside, feet	Total depth of hole, feet
			Outcrop No. I.		
8	nil	35	5	20	60
9	5	nil	12	33	50
10	nil	24	nil	26	50
11	nil	8	14	28	50
12	nil	104	15	36	155
13	nil	110	5	25	140
14	nil	nil	nil	100	100
15	10	117	16	32	175
16	nil	nil	27	73	100
17	5	nil	nil	75	80
18	nil	nil	51	29	80
19	20	nil	nil	nil	20
20	20	104	36	20	180
			Outcrop No. II.		
21	nil	nil	nil	50	50
22	nil	4	77	44	125
23	2	51	5	32	90
24	nil	102	16	22	140
25	nil	40	4	46	90
26	nil	nil	nil	60	60
27	nil	25	3	47	75
28	nil	26	2	47	75
		Unexposed area between outcrops II and III.			
29	5	88	31	18	142
30	11	nil	92	35	138
31	17	nil	22	17	56
32	20	nil	34	18	72
			Outcrop No. III.		
1	nil	67	1	52	120
2	nil	83	34	23	140
3	nil	75	30	2	107
4	nil	33	4	3	40
5	nil	66	2	30	98
6	nil	75	5	25	105
7	nil	nil	nil	60	60

[1]Estimated.

In mining the magnesite on the property the ordinary open-cut quarrying method with boom derricks and hoists is employed (Plate XI). The large masses of serpentine and dolomitic material encountered in the pits are unloaded into cars and transferred to the dumps directly. The magnesite on the other hand, is transferred to cobbing platforms where it is broken and cobbed.

The equipment on the property includes a number of boilers having a total capacity of 350 horse-power, 3 air compressors, 4 double drum hoists, 4 derricks, numerous drills, pumps, and other necessary machinery.

Camp buildings for the accommodation of 200 men have been built on the property and a light railway 14 miles in length has been constructed to the deposits from a point on the Canadian Pacific railway 2 miles east of Grenville station. In laying this railway long ties were used so that in the future if necessary it could be transformed to a broad gauge track. The necessary light locomotives and cars for the operation of the railway have also been procured.

LOT 15, RANGE X, GRENVILLE TOWNSHIP.

Deposits of magnesite or magnesite-dolomite are known to occur in two localities on this property. One of these deposits lies at the north end of the lot and near the west side of the railway leading to the pits of the Scottish Canadian Magnesite Company on the adjoining iot in range XI. The other deposit occurs at the south end of the lot adjoining the deposits of the North American Magnesite Company on lot 15, range IX. The northern deposit occurs in association with an outcrop of diopside which extends for nearly 600 feet along the eastern edge of a ridge of garnet gneiss and quartzite. It consists largely of dolomite and, while material of better quality may possibly underlie the clay flat adjoining the deposit, in its exposed portions at least it is not sufficiently extensive to be of commercial value.

The southern deposit on this property lies on the northern edge of the ridge of magnesite, magnesite-dolomite, and serpentine, which outcrops at the north end of the McPhee property (lot 15, range IX, Grenville township). The extent and geological relationships of the occurrence are indicated in outcrop No. 4, on Map 1679, and the physical character and lime content of samples collected from the surface of the deposit are given in Table VI. Of the exposed portion of the outcrop, 35 per cent consists of magnesite containing less than 12 per cent CaO; 55 per cent consists of magnesite-dolomite containing more than 12 per cent CaO; and the remaining 10 per cent consists of serpentine. Since the portion of the deposit hidden by rock debris underlies the bottom of the pit where the material of best quality probably occurs, it may be assumed that the proportion of magnesite relative to magnesite-dolomite and serpentine present in the exposed portions of the deposit is at least not less than that for the whole deposit; and from the following data the tonnage of magnesite in the deposit can be estimated.

Area, 30,000 square feet.
Percentage of magnesite containing less than 12 per cent CaO, 35.
Percentage of magnesite-dolomite containing more than 12 per cent CaO, 55.
Assumed depth, 25 feet.
Quantity of magnesite, 2,500 tons.
Quantity of magnesite-dolomite, 4,000 tons.

A few tons of magnesite were mined from this deposit by the Scottish Canadian Magnesite Company, owners of the property, during the winter of 1915, but since that time no work on the deposit has been attempted.

Table VI. Physical Character and Lime Content of Samples of Magnesite from Outcrop of Magnesite on Lot 15, Range X, Grenville Township.

No.	Colour	Lustre	Grain	Per cent of cob.	Per cent of CaO
1	speckled-grey	dull	fine	nil	18·00[1]
2	snow-white	glistening	fine	75	12·00[1]
3	milk-white	glistening	fine	nil	11·56[2]
4	milk-white	glistening	fine	nil	12·00[1]
5	speckled-grey	dull	fine	nil	18.00[1]
6	speckled-grey	glistening to dull	fine	nil	15·00
7	milk-white	glistening	fine	nil	13·78[2]
8	milk-white and grey	glistening	fine	nil	14·00
9	milk-white and grey	glistening	fine	nil	11·00
10	speckled and grey	dull	fine	nil	15·00
11	snow-white and milk-white	glistening	fine	nil	10·29[2]
12	snow-white milk-white	glistening	fine	10	11.00

[1] Estimated.
[2] Determined by Miss D. M. Stewart, Mines Branch, Department of Mines.

LOT 15, RANGE IX, GRENVILLE TOWNSHIP, MCPHEE PROPERTY.

The principal deposit on this property occurs at the extreme north end of the lot. At this point a ridge of magnesite and magnesite-dolomite approximately 1,000 feet long and from 100 to 300 feet wide extends northeasterly along the east shore of Whiterock lake. The physical character and the lime content of samples from the surface of this ridge are given in Table VII, and the proportions of magnesite, magnesite-dolomite, and serpentine contained in the diamond drill cores (drilled by the Harbison-Walker Refractories Company of Pittsburg) are summarized in Table VIII. The sample areas to which the numbers in Table VII refer are shown in outcrop V on Map 1679. The geological relationships of the deposit are shown in Map 1674.

Northern Part of Ridge.

In the northern part of the ridge there is a total area of approximately 75,000 square feet, of which 10,000 square feet (areas 1 to 53, outcrop V, Map No. 1679) are composed as follows:

Magnesite containing less than 12 per cent CaO, 25 per cent.
Magnesite-dolomite containing more than 12 per cent CaO, 40 per cent.
Serpentine, 35 per cent.

In the six diamond drill cores drilled in this part of the ridge (see table VIII) the proportions of magnesite, magnesite-dolomite, and serpentine are as follows:

Magnesite, 17 per cent.
Magnesite-dolomite, 57 per cent.
Serpentine, 26 per cent.

It might be pointed out in this connexion, however, that at least ten additional diamond drill holes would be required before the extent and quality of the material contained in the northern part of the ridge on the McPhee property can be regarded as fully determined.

Since the areas on the surface of the ridge from which samples were taken (Nos. 1 to 53) are widely separated, it is probable that the average percentages of magnesite and magnesite-dolomite obtained in these samples are closer to the percentages actually present (in the upper parts of the ridge at least), than the average obtained from the diamond drill cores. If, in estimating the number of tons of magnesite and magnesite-dolomite present in the northern part of the ridge, therefore, the lower average obtained for each constituent (17 per cent for magnesite and 40 per cent for magnesite-dolomite) be assumed to be present, it is reasonably certain that the resultant estimates will represent the minimum number of tons actually present.

The data from which a minimum estimate can be made follow:

Horizontal extent, 75,000 square feet.
Proved average depth, 100 feet.
Assumed average proportion of magnesite, 15 per cent.
Assumed average proportion of magnesite-dolomite, 40 per cent.
Number of cubic feet of magnesite and magnesite-dolomite in 1 ton, 12.

On the basis of the preceding data it is estimated that 94,000 tons of magnesite and 250,000 tons of magnesite-dolomite are present in the northern part of the McPhee outcrop; but, until a market is procured for the magnesite-dolomite, it is probable that not more than 25,000 tons of the 94,000 tons of magnesite in the above estimate could be profitably mined.

Southern Part of Ridge.

In the southern part of the outcrop on the McPhee property there is an exposed area of 32,000 square feet, composed approximately as follows (see areas 54 to 135, outcrop V, map No. 1679, and table VII):

Magnesite, 70 per cent.
Magnesite-dolomite, 20 per cent.
Serpentine, 10 per cent.

Within this area two diamond drill holes, Nos. 39 and 40, have been drilled. Of these No. 39 was drilled to a depth of 180 feet, but No. 40 was started only a few feet to the east of an eastward dipping lens of dolomite (see Map 1679 area 97) and in consequence dolomite was encountered at a depth of 15 feet, and after proceeding 9 feet in this material drilling was discontinued. There is, therefore, no information available with regard to the extent of the magnesite on the southern part of the McPhee outcrop at depth except in the vicinity of drill hole 39, and, on this account, the following estimate of tonnage in sight is probably somewhat lower than the actual amount present.

On the basis of the usual assumptions the tonnage of magnesite and magnesite-dolomite in sight in the southern part of the McPhee outcrop can be determined from the following data:

Adjacent to hole No. 39:
Horizontal extent, 5,000 square feet.
Proved depth, 200 feet.
Assumed proportion of magnesite, 70 per cent. (Table VIII.)
Assumed proportion of magnesite-dolomite, 15 per cent. (Table VIII.)

Not adjacent to hole No. 39:
Horizontal extent, 27,000 square feet.
Assumed depth, 50 feet.
Assumed proportion of magnesite, 65 per cent. (Table VIII.)
Assumed proportion of magnesite-dolomite, 15 per cent. (Table VIII.)
Number of cubic feet of magnesite and magnesite-dolomite in 1 ton, 12.

The number of tons of magnesite and magnesite-dolomite present is, therefore, as follows:

Locality	Magnesite, tons	Magnesite-dolomite, tons
Adjacent to hole 39	58,300	12,500
Portion not adjacent to hole 39	73,100	16,900
Total	131,400	29,400

In the southern part of the McPhee property a small mass of magnesite was observed in association with diopside on the west side of the road to the property at a point approximately 300 yards south of the main outcrop, and farther southward on the east side of the road dolomite is exposed for a width of approximately 20 feet. While these occurrences are of interest in that they indicate the possible occurrence of magnesite underlying the clay flat at these points, the material actually exposed is not of sufficient extent to be of commercial importance.

A summarized statement of the tonnage of magnesite and magnesite-dolomite known to be present on the McPhee property is as follows:

	Magnesite, tons	Magnesite-dolomite, tons
Northern part of outcrop	94,000	250,000
Southern part of outcrop	132,400	29,400
Total	226,400	279,400

Table VII. Physical Character and Lime Content of Samples of Magnesite from Magnesite Outcrops on Lot 15, Range IX, Grenville Township.

No.	Colour	Lustre	Grain	Per cent of cob.	Material cobbed	Per cent of CaO	Per cent of CaO in material cobbed[3]
1	grey	glistening to dull	fine	nil	....	14·00[1]	
2	snow-white	glistening to dull	fine	25	dull white magnesite-dolomite	12·00[1]	28·00
3	snow-white	shining	medium	nil	....	13·00[1]	
4	white	shining	coarsely crystalline	nil	....	15·00[2]	
5	snow-white	glistening	fine to medium	25	dull white magnesite-dolomite	13·00[1]	28·00
6	white	glistening to dull	fine to medium	nil	....	17·00[1]	
7	snow-white	glistening	fine to medium	nil	....	17·78[2]	
8	snow-white	glistening to dull	fine to medium	nil	....	10·26[2]	
9	snow-white	glistening	fine to medium	nil	....	10·00[2]	
10	snow-white	glistening	fine to medium	5	grey magnesite-dolomite	11·00[1]	17·00
11	snow-white	glistening	fine to medium	25	grey magnesite-dolomite	11·00[2]	18·00
12	snow-white	glistening	fine to medium	4	grey, serpentinous magnesite-dolomite	12·00[2]	16·00
13	snow-white	glistening and shining	fine to medium	25	grey, serpentinous magnesite-dolomite	13·00[1]	16·00 16·00
14	snow-white	glistening and shining	fine	nil	....	12·00[1]	
15	snow-white and speckled grey	glistening and dull	fine	nil	....	13·68[2]	
16	speckled grey	glistening and dull	fine to medium	nil	....	15·00[1]	
17	snow-white and grey	shining	coarse	25	grey, serpentinous magnesite-dolomite	14·00[1]	28·00
18	snow-white and milk-white	shining	medium	25	grey serpentinous dolomite	12·00[1]	
19	grey	dull	fine to medium	nil	....	18·00[1]	
20	snow-white and pink	glistening	fine	nil	....	11·00[1]	
21	snow-white	glistening	medium to fine	nil	....	12·13[2]	
22	white	dull	fine to medium	nil	....	16·00[2]	
23	snow-white and pink	glistening	fine	nil	....	13·00[1]	
24	snow-white	glistening	fine	nil	....	13·59[2]	
25	grey to white	shining	medium	nil	....	15·00[1]	
26	grey	dull to glistening	fine to medium	nil	....	14·00[1]	
27	grey	dull	fine	nil	....	16·00[1]	
28	snow-white and pink	glistening	fine to medium	nil	....	10·16[2]	
29	milk-white and grey	shining	medium	nil	....	14·00[1]	
30	milk-white and grey	glistening	fine	25	serpentine	13·00[1]	
31	snow-white to milk-white	glistening to shining	medium to fine	nil	....	13·00[1]	
32	grey	glistening to dull	fine to medium	50	grey magnesite-dolomite	12·00[1]	16·00
33	snow-white to milk-white	glistening	fine	nil	....	7·76[2]	
34	snow-white to milk-white	glistening	fine	nil	....	8·00[1]	
35	snow-white to milk-white	glistening	fine	25	grey serpentine	9·00[2]	
36-37	snow-white to milk-white	glistening	medium to fine	nil	....	11·00[1]	
38	snow-white and grey	glistening	fine	nil	....	13·94[2]	
39	grey	dull	fine	nil	....	10·00[1]	
40	snow-white to cream-white	glistening	fine to medium	nil	....	8·53[2]	
41	snow-white	glistening	fine	nil	....	9·00[1]	
42	milk-white and grey	glistening and dull	fine to medium	nil	....	13·00[2]	
43	grey and snow-white	glistening, shining, and dull	fine to medium	nil	....	12·00[1]	
44	grey and snow-white	glistening	fine to medium	30	grey, serpentinous magnesite-dolomite	11·15[2]	18·00
45	grey	glistening and shining	medium	nil	....	17·00[1]	
46	snow-white	glistening and shining	fine and medium	nil	....	12·00[1]	

Table VII.—Continued.

No.	Colour	Lustre	Grain	Per cent of coh.	Material cohbed	Per cent of CaO	Per cent of CaO in material cobbed
47	grey	glistening	fine and medium	nil		17·00[1]	
48	milk-white to grey	shining	fine and medium	nil		15·00[1]	
49	snow-white, milk-white, and grey	glistening	fine to medium granulated	10	yellow serpentine	12·00[1]	
50–51	cream white, milk-white	glistening	fine	nil		11·00[1]	
52	cream white to milk-white	glistening and shining	fine to medium	nil		10·44[2]	
53	cream-white, medium to grey	glistening and shining	fine to medium	nil		12·00[1]	
54	cream-white and snow-white	glistening	fine	25	grey magnesite-dolomite	11·00[1]	16·00
55	cream-white to milk-white and grey	glistening	fine to medium	20	grey serpentinous magnesite-dolomite	12·00[1]	
56	cream-white and milk-white	glistening	fine	15	coarse, grey dolomite 10%, yellow serpentine 5%	9·00[1]	16·00
57	cream-white and grey	glistening	fine	nil		9·00[1]	
58	snow-white, milk-white, and grey	glistening and shining	fine to medium	30	grey, serpentinous magnesite-dolomite	13·00[1]	18·00
59	snow-white to grey	glistening	fine to medium	nil		9·20[2]	
60	snow-white and grey	glistening	fine	nil		10·00[1]	
61	milk-white	glistening	fine	nil		9·00[1]	
62	cream-white and milk-white	glistening	fine and medium	20	yellow serpentine and grey magnesite dolomite	8·00[1]	
63	cream-white and milk-white	glistening	fine	10	grey magnesite-dolomite	8·00[1]	13·00
64	snow-white and grey	glistening	fine to medium	nil		9·97[2]	
65	cream-white and grey	glistening	fine and medium	nil		10·00[1]	
66	snow-white, milk-white, and grey	glistening	fine	10	grey, serpentinous magnesite-dolomite	9·00[1]	13·00
67	snow-white to milk-white	glistening	fine to medium	nil		8·00[1]	
68	milk-white	glistening	fine, granulated	nil		14·05[2]	
69	snow-white and grey	glistening	fine	10		11·00[1]	
70	snow-white and grey	glistening	medium to coarse	nil		9·00[1]	
71	cream-white to snow-white	glistening	fine to medium	10	grey, serpentinous magnesite-dolomite	8·00[1]	15·00
72	cream-white and snow-white	glistening	fine to medium	3	yellow serpentine	17·27[2]	
73	snow-white	glistening	fine	5	coarse, white dolomite	8·00[1]	28·00
74	grey	glistening to dull	fine	nil		13·00[1]	
75	snow-white and milk-white	glistening	fine	20	coarse dolomite 15%, serpentine 5%	7·00[1]	
76	cream-white to grey	glistening	fine	75	coarse dolomite	10·00[1]	25·00
77	snow-white	glistening	fine	nil		7·00[1]	
78	white and grey	shining and dull	medium to coarse	25	yellow serpentine	15·00[1]	
79	snow-white, milk-white, and grey	glistening	fine	20	grey magnesite-dolomite	8·00[1]	13·00
80	cream-white, milk-white, and snow-white	glistening	fine	nil		9·00[1]	
81	snow-white and grey	glistening	fine	5	yellow serpentine	8·00[1]	
82	cream-white, snow-white, and milk-white	glistening	fine	10	yellow serpentine	8·00[1]	
83	snow-white, milk-white	glistening	fine and medium	nil		6 00[1]	
84	snow-white and milk-white	glistening	fine	nil		5·61[2]	
85	snow-white and milk-white	glistening	fine	5	dull white magnesite dolomite	8·00[1]	26·00
86	snow-white and milk-white	glistening	fine and medium	nil		9·00[1]	
87	snow-white, milk-white	glistening	fine	20	serpentine 10%, coarse dolomite, 10%	10·00[1]	28 00
88	snow-white and grey	glistening and dull white	fine	nil		12·23[2]	

Table VII.—Continued.

No.	Colour	Lustre	Grain	Per cent of cob.	Material cobbed	Per cent of CaO	Per cent of CaO in material cobbed[1]
89	snow-white, milk-white, and grey	glistening and dull	fine	10	grey serpentinous magnesite-dolomite	10·00[1]	15·00
90	snow-white and grey	glistening	fine	nil		9·00[1]	
91	snow-white and grey	glistening and shining	medium	nil		13·00[1]	
92	snow-white, milk-white, and grey	glistening	fine	nil		10·00[1]	
93	grey and snow-white	glistening and shining	fine and coarse	nil		14·00[1]	
94	grey	shining and dull	coarse and fine	nil		18·00[1]	
95	cream-white, snow-white, and grey	glistening	fine	5	green serpentine	9·00[1]	
96	cream-white, snow-white, and grey	glistening	fine	nil		8·00[1]	
97	white	glistening	coarse	nil		22·00[1]	
98	snow-white, milk-white, and grey	glistening and shining	fine and medium	nil		10·00[1]	
99	snow-white, milk-white, and cream-white	glistening	fine	nil		6·00[1]	
100	snow-white and grey	glistening	fine and coarse	nil		9·00[1]	
101	cream white and milk-white	glistening	fine	5		6·07[2]	
102	snow-white, milk-white, and grey	glistening	fine	nil		7·00[1]	
103–104	milk-white and grey	glistening	fine and medium	nil		10·00[1]	
105	snow-white	glistening	fine	5	coarse dolomite containing pyrite	7·80[2]	
106	snow-white and milk-white	glistening	fine	nil		8·00[1]	
107	snow-white and grey	glistening	fine	10	serpentine	10·00[1]	
108	snow-white and grey	glistening	fine and medium	25	yellow serpentine	12·00[1]	
109	snow-white and grey	glistening	fine and medium	25	dull white dolomite	10·00[1]	18·00
110	snow-white and grey	glistening	fine	nil		9·00[1]	
111	snow-white and milk-milk	glistening	fine and medium	nil		9·49[2]	
112	milk-white	glistening	medium	nil		9·00[1]	
113	grey	glistening	medium	nil		11·00[1]	
114	grey	shining	coarse	nil		25·00[1]	
115	milk-white	glistening and shining	medium to coarse	nil		8·84[2]	
116	cream white, snow-white, and grey	glistening and shining	fine	nil		6·07[2]	
117	snow-white	glistening	fine and medium	nil		3·93[1]	
118	snow-white and milk-white	glistening	medium	nil		7·00[1]	
119	snow-white and milk-white	glistening	medium and fine	nil		9·00[1]	
120	snow-white and milk-white	glistening	medium	25	yellow serpentine	10·00[1]	
121	milk-white	glistening	fine and medium	nil		10·00[1]	
122–123	snow-white and milk-white	glistening	fine and medium	nil		10·00[1]	
124	snow-white	glistening	fine	nil		8·00[1]	
125	snow-white and grey	glistening	fine	5	green serpentine	9·00[1]	
126	snow-white and milk-white	glistening	fine	10	green serpentine	10·00[1]	
127–128	milk-white and grey	glistening	fine and medium	nil		11·00[1]	
129	snow-white, milk-white, and grey	glistening	fine	10	grey serpentine	10·00[1]	
130	snow-white and grey	dull and glistening	fine	nil		16·00[1]	
131–132	snow-white, milk white, and grey	glistening	fine and medium	5	grey magnesite-dolomite	11·00[1]	14·00
133	snow-white	glistening	fine	nil		10·00[1]	
134	snow-white	glistening	fine	10	grey magnesite-dolomite	9·00[1]	14·00
135	snow-white and milk-white to grey	glistening	fine to medium	nil		9·00[1]	

[1] Estimated.
[2] Determined by Miss D. M. Stewart, Mines Branch, Department of Mines.

Table VIII. Summary Description of Diamond Drill Cores from Magnesite Deposit on Lot 15, Range IX, Grenville Township.[1]

No. of hole	Magnesite containing less than 12 per cent CaO, feet	Average CaO content of magnesite	Magnesite-dolomite containing more than 12 per cent CaO, feet	Serpentine, feet	Total depth of hole, feet
33	23	9·09	86	31	140
34	21	10·48	53	10	85
35	9	9·60	28	43	80
36	9	11·47	30	46	85
37	15	10·80	35	7	57
38	15	9·95	79	6	100
39	140½	7·40	32½	7	180
40	15	7·33	9	..	24

The magnesite is mined at the McPhee property as elsewhere in the district by the open-cut method. The magnesite is cobbed as broken down at the pit's face and loaded directly into wagons (or sleighs in winter) and the waste rock is carted to the dumps.

The equipment on the property includes a 10-ton keystone kiln, four retort furnaces, a mill for grinding the calcined magnesite, a cableway for hoisting the ore into the kiln (Plate X), a number of boilers, steam drills, pumps, and other machinery necessary for quarrying operations. Camp buildings having accommodation for 100 men have been erected on the property and a road 11 miles in length has been constructed from the magnesite deposit to the Canadian Pacific railway at Calumet.

LOT 13, RANGE IX, GRENVILLE TOWNSHIP.

The southern part of this lot is occupied by a high ridge of garnet and granite gneiss on the northern slope of which, adjoining the clay flat which extends along Magnesite creek, outcrops of dolomite are exposed. One of these deposits, situated on the east side of the lot about 200 feet to the north of the road crossing the property, is approximately 40 feet long and 20 feet wide; and another occurring about 100 yards farther down the hill to the northwest is exposed for 30 feet in the bottom of a trench. The dolomite contained in these deposits is a coarsely crystalline white variety containing disseminated grains of wax yellow serpentine and flakes of graphite. Since dolomite has little or no commercial value, these deposits are of importance at the present time only in so far as they indicate the possible occurrence of magnesite in their vicinity. If, in the future, a market for dolomite should be procured, they might become valuable; but additional development work would be required to prove their extent.

[1] Analyses by J. T. Donald and Co., Montreal.

LOT 16, RANGE IX, GRENVILLE TOWNSHIP.

This lot lies on the eastern margin of a batholithic mass of granite gneiss and, except at points along its eastern boundary where embayments in the batholithic margin occupied by rocks of the Grenville series occur, is entirely underlain by gneiss. The most extensive area of rocks belonging to the Grenville series, on the property, underlies a drift covered depression at the southeast corner of the lot and it is in association with these rocks that a mass of dolomite and magnesite-dolomite has been discovered.

At the time the property was examined by the writer in August, 1916, the only indications of magnesite at this point were a few large boulders of magnesite in the drift and a northeasterly trending ledge of quartzite and diopside about 3 feet wide and 20 feet long, exposed in the bed of a small creek. There was a parallel, drift-covered ridge about 40 feet wide and 300 feet long adjoining this outcrop on the southeast, however, which had the elliptical form and conformable trend common to all the magnesite deposits. A pit was excavated in the drift by Messrs. Fitzsimmons and Boshart with the result that a deposit of magnesite-dolomite and dolomite containing included masses of diopside was disclosed. When the deposit was visited by the writer in January, 1917, a pit approximately 30 feet square had been excavated, the bottom of which was underlain entirely by this material, but up to that time no No. 1 magnesite had been discovered.

LOT 11, RANGE VIII, NORTH, GRENVILLE TOWNSHIP, CAMPBELL PROPERTY.

At a distance of 100 feet to the north of the road which crosses the south end of this lot a dolomitic magnesite was exposed along the whole length of the bottom of a 50-foot trench. This dolomitic magnesite is a medium-grained, uniform, white, crystalline material containing disseminated grains of wax-yellow serpentine. The lime content of the dolomitic magnesite has not been determined chemically, but the physical character indicates that it probably contains at least 20 per cent.

LOT 12, RANGE VIII, NORTH, GRENVILLE TOWNSHIP.

The deposit of magnesite-dolomite on lot 12, range VIII north, Grenville township, consists of a group of large boulders situated near the south end of the lot at a point a few hundred feet east of Calumet creek and about 400 feet northwest of the dolomitic magnesite exposed in the bottom of a trench on lot 11. Whether the boulders comprising this deposit have been derived from the underlying bedrock cannot be positively determined, but their similarity to the bedrock a few hundred feet eastward indicates that such is possibly the case.

A sample of the boulder material, collected by R. L. Broadbent, was analysed by R. A. A. Johnston of the Geological Survey with the following result:

Magnesium carbonate	66·38 per cent
Calcium carbonate	23·96 "
Magnesia in other form than carbonate	4·86 "

LOT 11, RANGE VIII, SOUTH, GRENVILLE TOWNSHIP.

Dolomitic magnesite is exposed in the bottoms of a pit 25 feet square and a trench 20 feet long, on the western slope of a drift covered ridge, near the northwest corner of this lot, and about 200 yards south of the dolomitic magnesite exposed in the bottom of trench on the Campbell property. The material exposed at these points is similar in every respect to the dolomitic magnesite found on the adjoining Campbell property and indicates that there is possibly a very extensive area of this material in that locality.

LOT 12, RANGE VIII, SOUTH, GRENVILLE TOWNSHIP.

An enormous boulder of fine, white glistening magnesite also occurs on lot 12, southwest of the exposure on lot 11, and about 200 feet west of Calumet creek. The larger part of the boulder is buried in clay and sand so that neither its whole extent nor its relationships to the underlying bedrock have been determined.

A shipment of 52 tons of magnesite derived from this boulder was made by Messrs. Fitzsimmons and Boshart during the summer of 1916.

LOT 9, RANGE XI, AUGMENTATION OF GRENVILLE.

Serpentinized dolomitic magnesite occurs on this lot on the east shore of Papineau or Commandant lake. At the point examined by the writer the dolomitic material formed a low point about 100 to 200 feet wide and several hundred feet long projecting northward between a small bay and the main expanse of the lake.

An average sample collected by the writer from the deposit and analysed by H. A. Leverin of the Mines Branch had the following composition.

$CaCO_3$	36·60
$MgCO_3$	63·66
Insol	0·10
Total	100·36

A deposit of similar material was reported to occur inland from the lake, but was not examined by the writer.

LOT 21, RANGE I, HARRINGTON TOWNSHIP.

Near the north end of this lot a triangular shaped mass of crystalline limestone belonging to the Grenville series projects into Rouge river forming what is generally known as Marble rapid. On the west the limestone adjoins a ridge of Grenville quartzite and along this contact there is a highwater channel so that the limestone mass becomes an island during periods of flood.

This insular mass of limestone has an approximate length of 250 feet and a width of 100 feet. It consists of medium-grained, crystalline limestone containing disseminated grains of wax yellow and reddish brown serpentine, and numerous nodular or lenticular masses of serpentine and coarse white dolomite. At one point an included mass of crystalline porous calcite was also observed. The disseminated serpentine is concentrated in bands which trend in a northeasterly direction and dip to the northwest thus conforming in their strike and dip to the structure of the adjoining quartzite. Near the north end of the mass a crumpled lens of graphitic coarse, white dolomite about 12 feet long was observed to be enclosed in banded limestone, the crumplings in which conformed to the plications in the dolomite mass, thus indicating clearly that the present form of the dolomite mass has resulted from deformation.

As far as was observed there is no magnesite in this locality and the amount of dolomite present is very limited. The deposit is of interest, however, in that its lenticular and banded structure is strikingly similar to that of the principal magnesite deposits of the district.

LOT 7, RANGE X, GRENVILLE TOWNSHIP.

Magnesite in place was not observed on this lot, but a number of boulders of fine glistening white magnesite of excellent quality occur near the north end of the property, which are of interest because they indicate the presence of an undiscovered deposit of magnesite in the district.

In the Grenville region the direction of glacial movement was approximately from north to south so that all boulders of magnesite which have been transported are found south of the deposit from which they were derived. It is obvious, therefore, that the boulders found on lot 7, range X, Grenville township, have not been derived from any of the known deposits in the district, but from an undiscovered deposit occurring either at the north end of lot 7 or northward in the direction of Green lake.

CHAPTER V.

SUMMARY AND CONCLUSIONS.

Some of the more important results of the study of the character, extent, and relationships of the Grenville magnesite deposits briefly stated are as follows:

The deposits are of early Pre-Cambrian age and occur in association with the metamorphosed group of sediments (crystalline limestone, sillimanite-garnet gneiss, and quartzite) known as the Grenville series.

All of the deposits so far discovered in the district occur in the major valleys in which stratified marine clay and sand have been deposited. Through this material the deposits outcrop in ridges or groups of ridges up to 1,000 feet in length and 300 feet in width.

The ridges in which the magnesite is found are composed mainly of magnesite, dolomite, serpentine, and diopside. The proportion of magnesite free from dolomite or dolomite free from magnesite in the deposits, however, is small, these minerals occurring for the most part intimately intermingled in varying proportions.

The deposits have all been so intensely deformed since their formation that masses of serpentine, dolomite, and other variations which they contain have been squeezed out into lenses.

The study of the character and relationships of the deposits has led to the conclusion that they are of metamorphic origin, and have been formed by the replacement of the limestone member of the Grenville series through the agency of magnesia-rich solutions.

While the magnesite everywhere includes more or less dolomite, diamond drilling and other development work have shown that extensive masses of magnesite are present in which the lime content resulting from the presence of the dolomite averages from 7 to 10 per cent.

A summarized statement of the number of tons of magnesite and magnesite-dolomite in sight in the various properties is as follows:[1]

Property	Magnesite containing less than 12 per cent CaO, tons	Magnesite-dolomite containing more than 12 per cent CaO, tons
Lot 13, range I, Harrington township....	25,000	8,000
Lot 18, range XI, Grenville township....	15,000	6,000
Lot 15, range XI, Grenville township....	418,000	186,300
Lot 15, range X, Grenville township.....	2,500	4,000
Lot 15, range IX, Grenville township....	226,400	279,400
Total..............................	686,900	483,700

[1] It must be noted in this connexion that these estimates have no definite relationship to the amount of magnesite present on the various properties since some deposits have been more extensively developed by diamond drilling and other development operations.

Of the above total, however, there is approximately 69,000 tons of magnesite on lot 15, range IX, and 10,000 tons on lot 15, range XI, that could not be profitably mined unless a market for magnesite-dolomite was procured.

Since the magnesite and magnesite-dolomite are, on the whole, less resistant to erosion than either the serpentine or the rocks of the Grenville series with which the deposits are associated, it is probable that the outcrops in which the magnesite occurs have little or no relationship to the actual distribution of the magnesite and that extensive masses of magnesite occur underlying the clay flat adjoining the outcrops.

Since the magnesite deposits are generally associated with the rocks of the Grenville series and since these rocks usually underlie valleys, the most favourable localities for prospecting for magnesite are the valleys, and especially those valleys where limestone and other members of the Grenville series are known to be present.

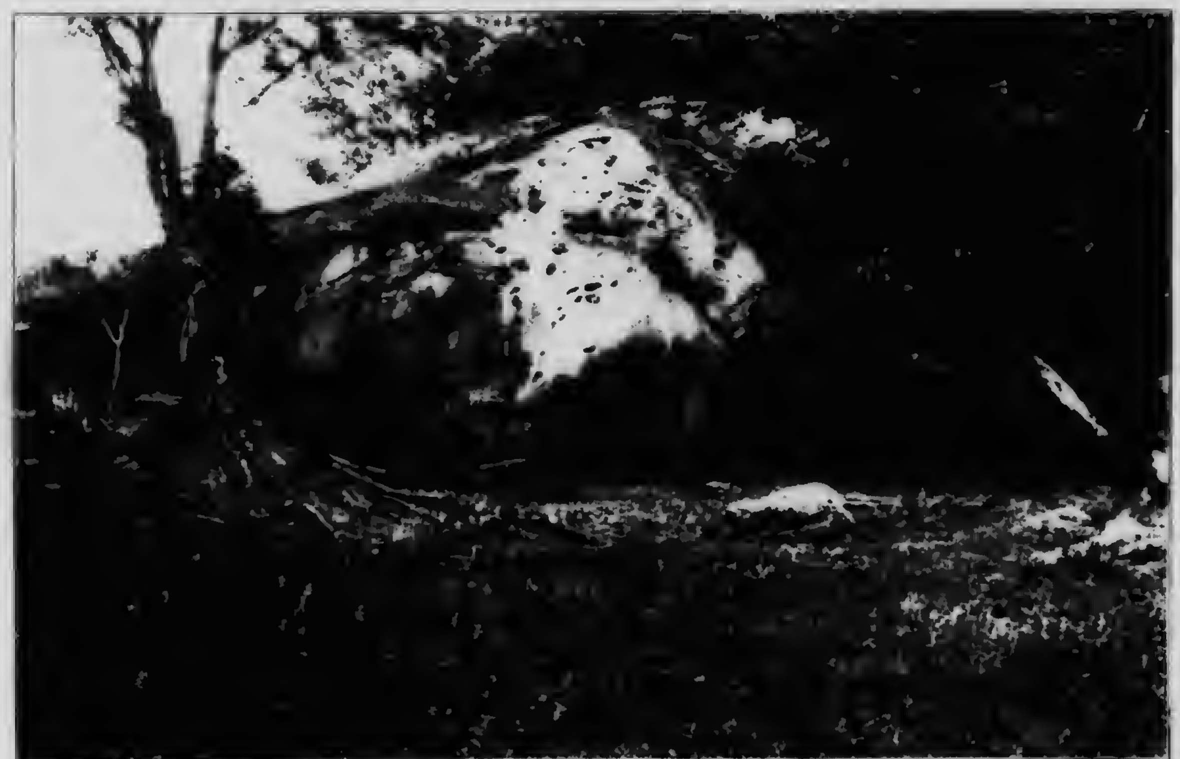
The occurrence of boulders of magnesite in localities where they could not possibly have been derived from the known occurrences of the material indicates that there are other undiscovered deposits of magnesite in the district.

PLATE II.

Weathered surface of crumpled sillimanite-garnet gneiss and quartzite, lot 22, range I, Wentworth township. (Page 20.)

PLATE III.

Banded crystalline limestone exposed in bed of West river, lot 20, range I, Wentworth township. (Page 20.)



Knob of crystalline limestone containing nodular inclusions of pegmatite and pyroxene syenite, occurring east of the Scotch road, lot 18, range IX, Grenville township. (Page 20.)

PLATE V.

Granite gneiss interbanded with and intruding pyroxenic gneiss of the Buckingham series. Note the numerous dykelets of granite connecting across the bands of pyroxenic gneiss. (Page 22.)

PLATE VI.

Weathered surface of magnesite-dolomite, lot 15, range IX, Grenville township. (Page 26.)

PLATE VII.

A. Calcined Grenville magnesite-dolomite; dark, magnesite; light, dolomite; natural size. (Page 26.)

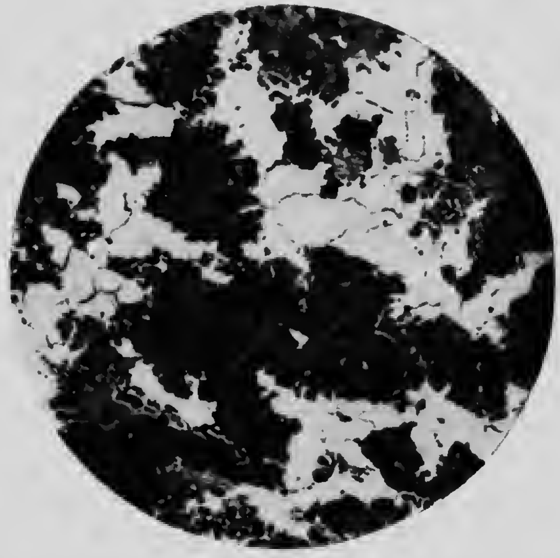
B. Calcined Grenville magnesite, showing inclusions of dolomite. (Page 26.)

MICROCOPY RESOLUTION TEST CHART

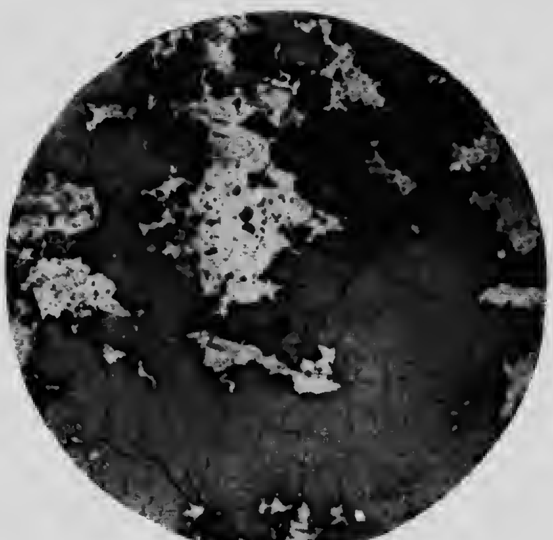
(ANSI and ISO TEST CHART No. 2)

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0 5.6 6.3 7.1 8.0 9.0

PLATE VIII.



A. Calcined Grenville magnesite-dolomite: dark, magnesite; light, dolomite; black spots, serpentine; enlarged two diameters. (Page 26.)



B. Grenville magnesite-dolomite calcined in a reducing atmosphere; enlarged two diameters. (Page 26.)

Disseminated grains of serpentinized diopside forming parallel bands in Grenville crystalline limestone, Buckingham, Quebec. (Page 32.)

Kiln and mill, North American Magnesite Company, on the McPhee property, lot 15, range IX, Grenville township. (Page 58.)

PLATE XI.

No. 3 pit on property of the Scottish Canadian Magnesite Company, lot 15, range XI, Grenville township. (Page 50.)

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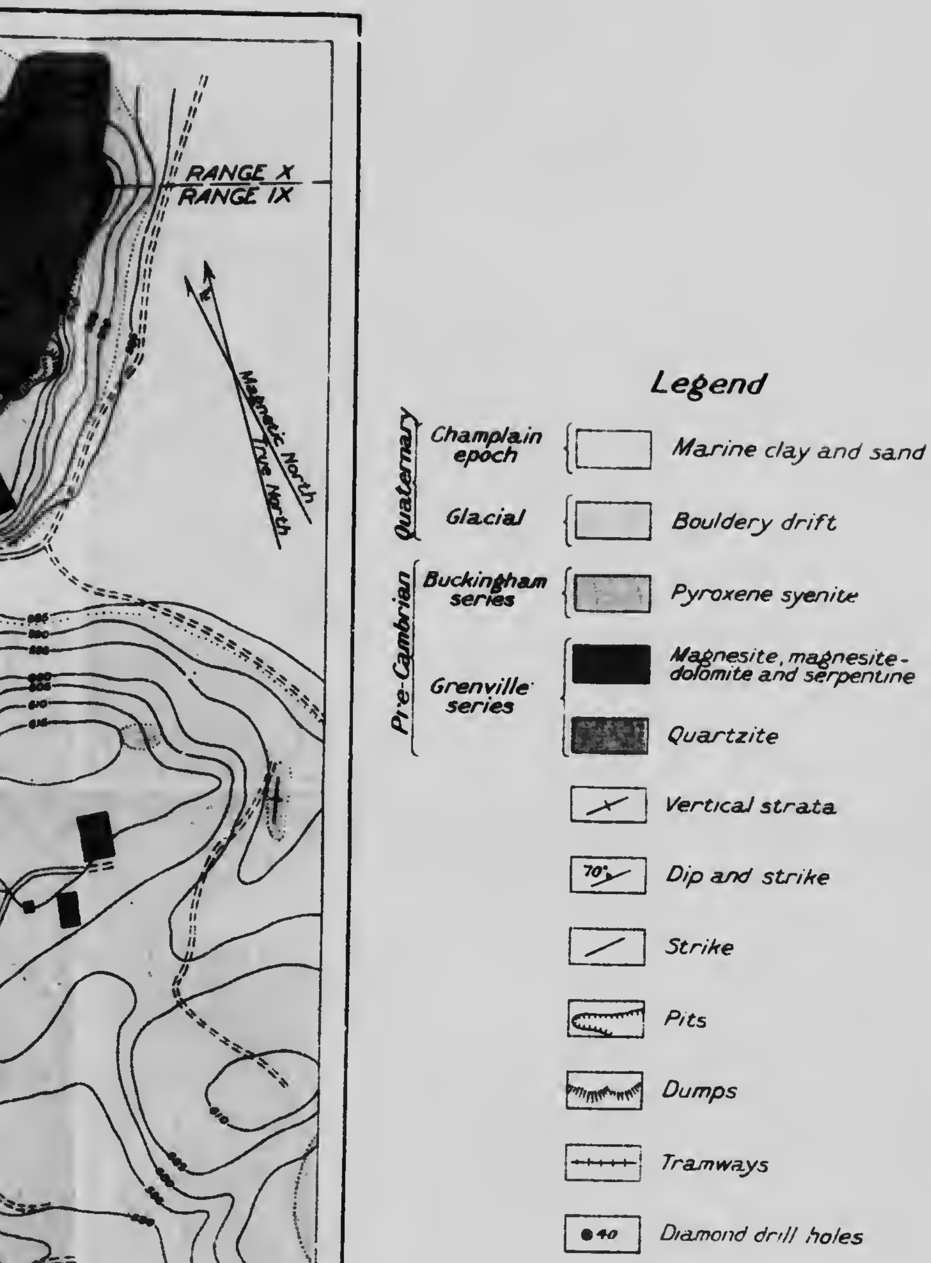
Geological Survey, Canada.

Diagram showing magnesite deposits,
Lots 15, ranges IX and X, Grenville township, Argenteuil

Scale of Feet
100 50 0 100 200 300

To accompany Memoir by M. E. Wilson.



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...posits,
...enteuil county, Quebec.


No. 2

Legend
Quaternary
Champlain epoch
Marine clay and sand
Glacial
Bouldery drift
Pre-Cambrian
Biotite granite gneiss
Diopside (Metamorphic pyroxenite)
Pegmatite
Buckingham series
Pyroxene syenite
Magnesite, magnesite-dolomite and serpentine outcrops
Magnesite, magnesite dolomite and serpentine, concealed by drift but ascertained by borings
Grenville series
Garnet gneiss
Quartzite
Dip and strike
Strike
Pits
Prospect pits
Diamond drill holes
Dumps
Tramways

Quebec.

Geological Survey, Canada

Diagram showing magnesite outcrops in Grenville town

To accompany Memoir by M.E. Wilson

Scale of Feet
50 0 50

ville township, Argenteuil county, Quebec.

Catalogue No 1679